PSO BASED OPTIMAL REACTIVE POWER DISPATCH (ORPD) CONSIDERING MULTI-CONTINGENCIES

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Outline

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Introduction

- The increasing number of voltage collapse occurrences due to voltage instability which involves heavy load and contingencies has motivated further research in voltage stability.
- The increment in load demands will decrease the reactive power and voltage, which leads to voltage collapse in the system.
- Voltage collapse has caused the power utility failed to function which may involve monetary loses.
- Therefore, an efficient voltage stability analysis technique is required in order to perform the voltage stability study.

Problems Statement

- Multi-contingencies events have been reported to be the practical disturbances experienced in power system network.
- Power system network these days does not face single contingencies (N-1), but (N-m) which implies that several component will involve which result in a voltage instability.
- The increment of reactive power demand in existing power transmission systems can cause a lacking in reactive power support.
- During contingencies, the operating generators fail to operate and cause the reactive power supply by generator suddenly drop.

Problems Statement cont.

- This phenomenon is a progressing issue, which requires a VSA analysis to be properly conducted especially at the planning stage.
- In optimization technique, numerous optimization problem have more than one objective function in conflict with each other.
- Therefore multi-objective is implemented into the system where trade-off between the difference components of the objective function is solved.

Methodology

Reactive Power Dispatch problem can be formulated mathematically as follows:

A. Objective Function

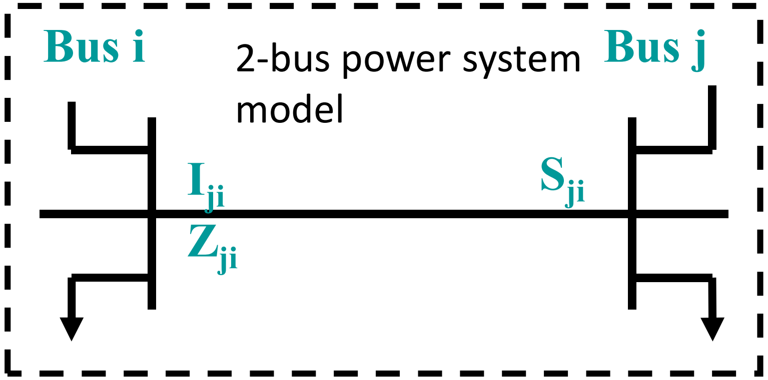
$$\text{minimize } SVSI_{ji} = \frac{2\sqrt{\left(X_{ji}^2 + R_{ji}^2\right)\left(P_{ji}^2 + Q_{ji}^2\right)}}{\left|V_i\right|^2 - 2X_{ji}Q_{ji} - 2R_{ji}P_{ji}}$$

where
- R_{ji} = the line resistance
- X_{ji} = the line reactance
- P_{ji} = the real power at the receiving end
- Q_{ji} = the reactive power at the receiving end
- Vi = the sending end voltage

Indicated the steady state voltage stability of the line

<1= stable

>1=unstable



Methodology

B. Inequality Constraint Equations

1: Voltage capability limit:

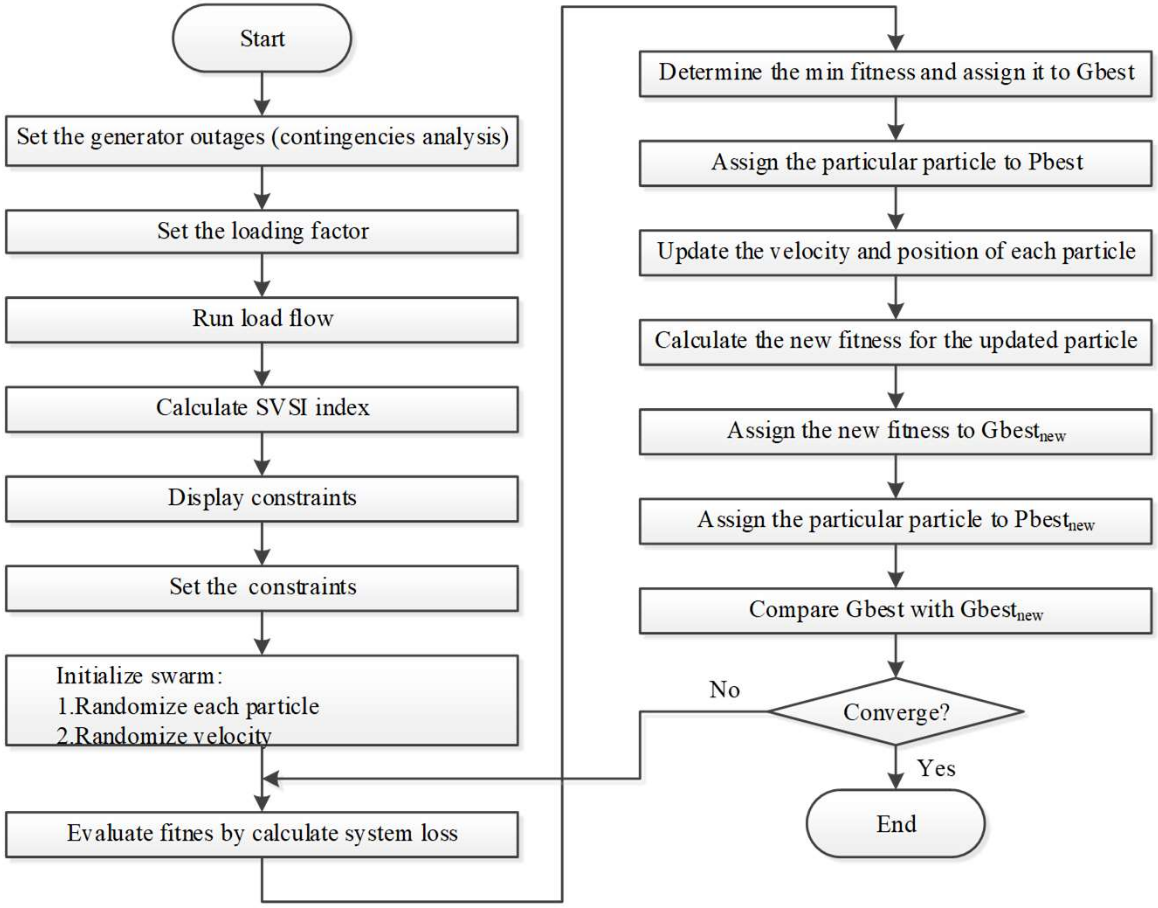
$$V_{i_{\min}} \leq V_i \leq V_{i_{\max}} \qquad i \in N_b$$

where N_b is the total number of buses

2: Active Power capability limit:

$$P_{Gi_{\min}} \leq P_{Gi} \leq P_{Gi_{\max}} \qquad i \in Slackbus$$

Flow chart for implementation of PSO for ORPD



Start

Set the generator outages (contingencies analysis)

Set the loading factor

Run load flow

Calculate SVSI index

Display constraints

Set the constraints

Initialize swarm:
1.Randomize each particle
2.Randomize velocity

Evaluate fitnes by calculate system loss

Determine the min fitness and assign it to Gbest

Assign the particular particle to Pbest

Update the velocity and position of each particle

Calculate the new fitness for the updated particle

Assign the new fitness to $\text{Gbest}_{\text{new}}$

Assign the particular particle to $\text{Pbest}_{\text{new}}$

Compare Gbest with $\text{Gbest}_{\text{new}}$

Converge?

No

Yes

End

CONTINGENCIES ANALYSIS

- This system has 6 generator buses and 24 load buses with 41 interconnected lines.
- All generators are removed consecutively one at a time except for generator at bus 1.

Table 1

Generator outage rank based *SVSI* in the IEEE 30-Bus RTS (Base case)

Rank	Gen Outage No.	Line No.	SVSI
1	13	5	0.1695
2	11	5	0.1694
3	2	5	0.1634
4	8	5	0.1611
5	5	15	0.1463

- Therefore a combination of several generators 2, 11 and 13 were selected to be outage.
- The selections of outages are based on the most severe generator in the system to maximize the performance of the system

Results And Analysis

- Analysis tested on the IEEE 30-bus RTS bus 26 subjected 25 MVAr loading and population of 10.
- First part: the results for ORPD with *SVSI* as the objective function
- Second part: the results for the comparative studies implemented between EP. In this study ORPD is performed to the system with bus 26 subjected 25 MVAr loading and population of 10.

Results and Analysis

Table 2: Effect of ORPD with load subjected to bus 26 using PSO (Loading, QL = 25 MVAr)

Generator Outage No.	Analysis	SVSI	Total Loss	% ΔLoss	Q_{g2}	Q_{g5}	Q_{g8}	Q_{g11}	Q_{g13}	V_m (p.u)
			(MW)		MW					
0	Pre	0.3636	22.267	26.7	28.085	34.941	54.632	21.586	17.693	0.7831
	Post	0.2113	16.328		77.703	-63.921	229.91	33.723	10.437	1.0394
13	Pre	0.3878	22.745	42.5	39.272	39.761	53.029	23.895	-	0.7564
	Post	0.2083	13.087		-18.814	32.093	180.302	64.722		1.0471
13, 11	Pre	0.4427	24.176	19.5	39.003	36.558	60.293	-	-	0.7032
	Post	0.2153	19.457		73.328	-75.648	297.957			1.0295
13, 11, 2	Pre	0.4482	25.762	35.9	-	43.633	67.508	-	-	0.6984
	Post	0.219	16.516			-25.299	281.201			1.0206

- All the *SVSI* values reduce as compared with pre-ORPD with respect to generator outage number variation.
- The voltage profiles in the system are also improved.
- The transmission losses are minimized.

Results and Analysis

Table 3 : Comparison results for ORPD between PSO and EP when bus 26 was reactively loaded

Line Outage No.	Pre			Post							
				PSO				EP			
	SVSI	Voltage (p.u.)	Loss (MW)	SVSI	Voltage (p.u.)	Loss (MW)	ΔLoss (%)	SVSI	Voltage (p.u.)	Loss (MW)	ΔLoss (%)
0	0.3636	0.7831	22.267	0.2113	1.0394	16.328	26.7	0.2947	0.8821	8.014	64
13	0.3878	0.7564	22.745	0.2083	1.0471	13.087	42.5	0.365	0.7815	9.376	58.8
11,13	0.4427	0.7032	24.176	0.2153	1.0295	19.457	19.5	0.3379	0.8143	8.174	66.2
2, 11, 13	0.4482	0.6984	25.762	0.219	1.0206	16.516	35.9	0.3468	0.8032	7.845	69.5

- PSO gives better results as compared to EP in terms of voltage stability; SVSI and voltage profile however EP manage to outperformed PSO in terms of transmission losses.

Conclusion

The result indicated that PSO and EP techniques had improved the result ; minimize voltage stability, reduce transmission losses and voltage profile

PSO technique outperformed EP in terms of voltage stability improvement and voltage profile.

Thank You

Q & A