EH2745 – Computer Applications in Power Systems

Assignment II

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System State Labeling

1. **High Load**

First, the sum of the voltage level that connected to the bus 5, bus 7, and bus 9 is needed to be calculated (the buses that connected to the load) because it represents the lower voltage level in "High Load" condition during peak hours. To determine the cluster, the sum was compared to certain upper and lower threshold. The threshold is obtained after analyzing the centroids. The condition for "High Load" can be expressed as below:

$$2.92 < |V_5| + |V_7| + |V_9| < 2.93$$

2. **Shut Down**

In this condition, the injected power to the bust where generator is located needs to be calculated in order to find if the generator is shut down. If the injected power is below 0.01 rad, it assumed that the generator in "Shut Down" condition. It can be expressed as:

$$P_{ij} = \frac{V_i \cdot V_j}{X_{ij}} \cdot \sin(\theta_i - \theta_j) \approx \theta_i - \theta_j$$

$$P_{14} \approx \theta_1 - \theta_4 \text{ and } P_{28} \approx \theta_2 - \theta_8 \text{ and } P_{36} \approx \theta_3 - \theta_6$$

In the algorithm, it can be represented in these equation:

$$(P_{14} < 0.01) \,||\, (P_{28} < 0.01) \,||\, (P_{36} < 0.01)$$

3. **Low Load**

   In the "Low Load" condition, it can also be determined by using the sum of the voltage level that connected to the bus 5, bus 7, and bus 9, but it needs to be higher than the threshold which is 2.97. The threshold is obtained after analyzing the centroids. The algorithm condition can be expressed as:

$$|V_6| + |V_7| + |V_8| > 2.97$$

4. **Disconnect**

   For Disconnect scenario, it can be detected by using voltage reduction, because when the line is disconnected, the current will be transverse using other lines, which means there will be significant voltage drop, as the result one of the buses will have low voltages. The threshold of the voltage is 0.85, which was determined after analyzing the cluster centroids.

$$|V_i| < 0.85 \text{ for at least one } i \in \{1, \ldots, 9\}$$

The Clustering Result

1. **High Load**   **:** 47 Samples
2. **Shut Down**   **:** 53 Samples
3. **Low Load**   **:** 51 Samples
4. **Disconnect**   **:** 49 Samples

The test set result using the KNN algorithms:

1. **High Load**   **:** 5 Samples
2. **Shut Down**   **:** 5 Samples
3. **Low Load**   **:** 5 Samples
4. **Disconnect**   **:** 5 Samples

Appendix Python Code

```python
#K-Label
def klabel(attributes):
    state = ""
#    Sum of voltages at bus 5,7,9
    sum579 = attributes[8]+attributes[12]+attributes[16]
    min_value = minValue(attributes)
#     buses 5, 7 and 9 have low voltages
    if sum579<2.92 and sum579>2.60:
        state = "High Load"
#     buses 6, 7 and 8 have high voltages
    elif sum579>2.97:
        state = "Low Load"
#    if one of these flows is too low, it means that the generator is offline
    elif attributes[1]-attributes[7]<0.01 or attributes[3]-attributes[15]<0.01 or
attributes[5]-attributes[11]<0.01:
        state = "Shut Down"
#    if one of voltage is below threshold, it has line disconnection
    elif min_value<0.85:
        state = "Disconnect"
    return state
```