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Machine Learning Embedded in Distribution Network Relays to Classify and Locate Faults

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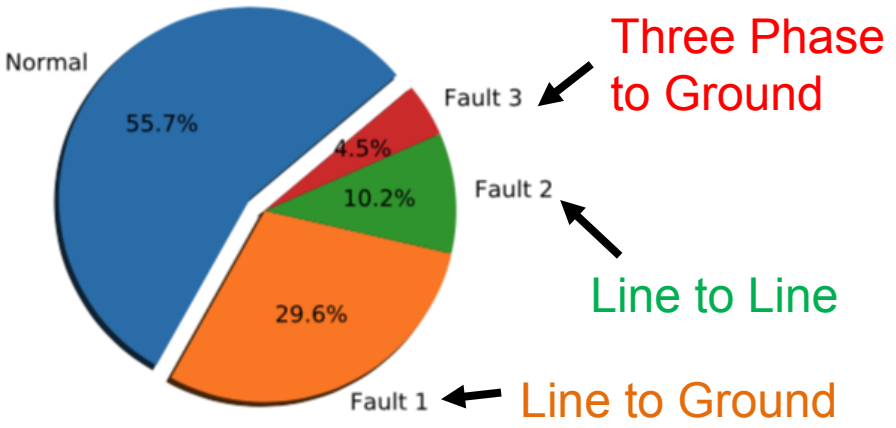
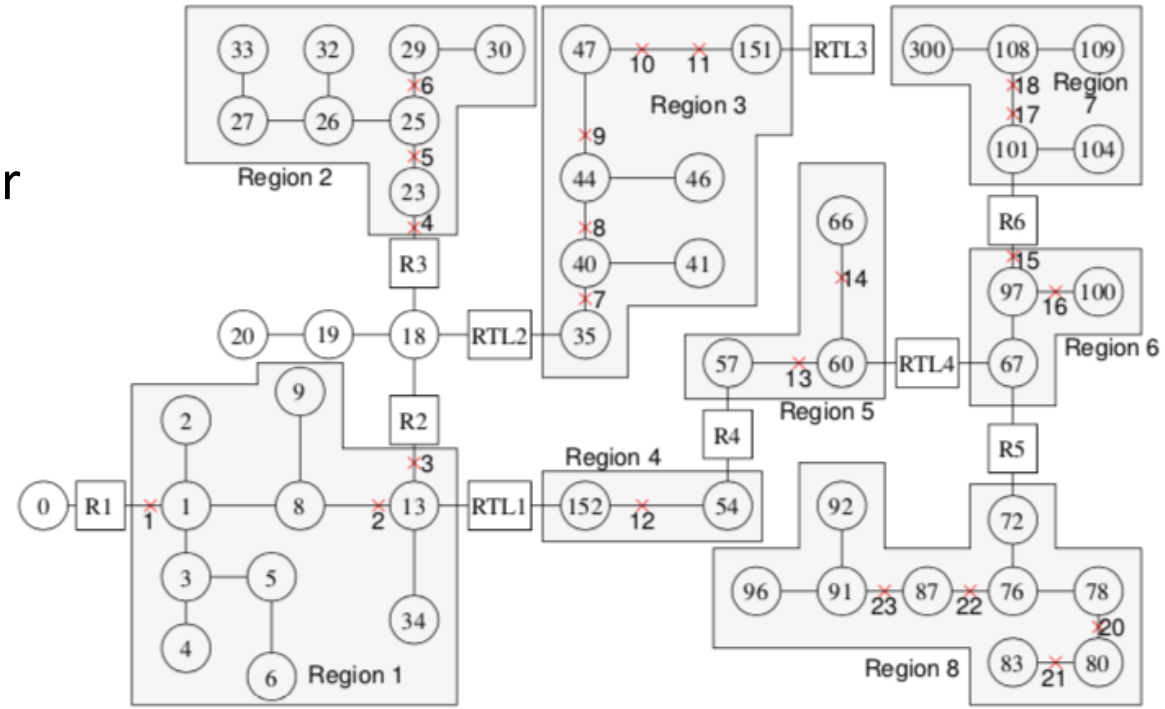
Introduction

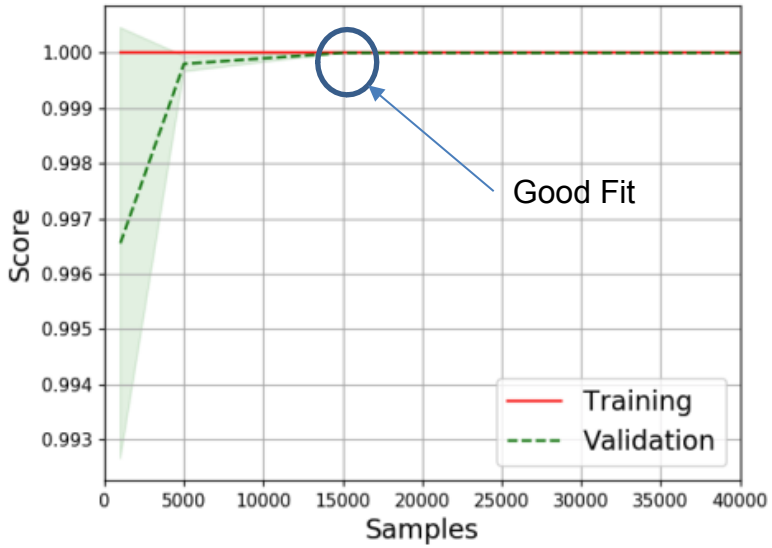


- What? - Machine Learning (ML) Fault Analysis
  - Using ML for power system protection instead of relays
  - Test approach on IEEE 123 Model (Matlab Simulink)
  - Simulate 3 fault types at 19 locations with varying resistances at different times of year
- Why? - Intelligent Decision Making
  - Coordinated switching
  - System specific learning that adapts
- Hypothesis
  - ML at each breaker can distinguish faults inside its protective zone/region

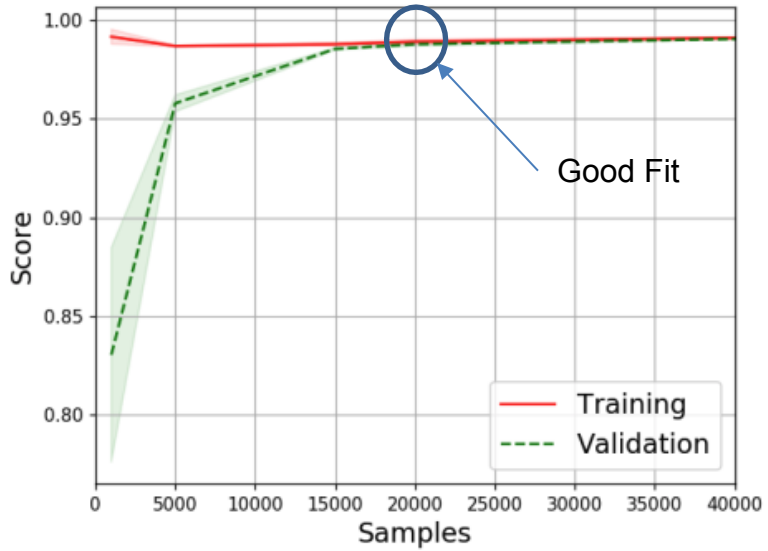


Training/Validation Assessment

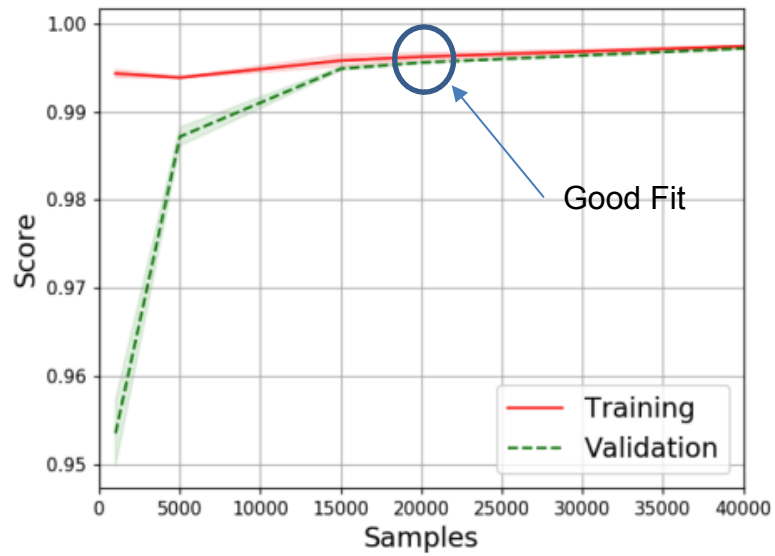
Fault Type



Fault Region



Breaker Decisions

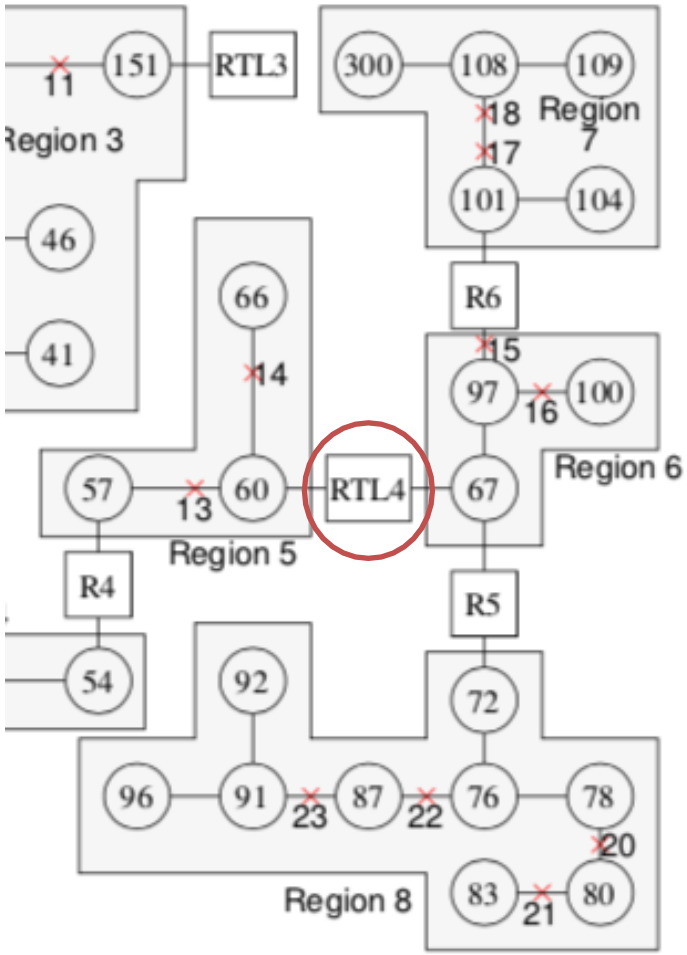


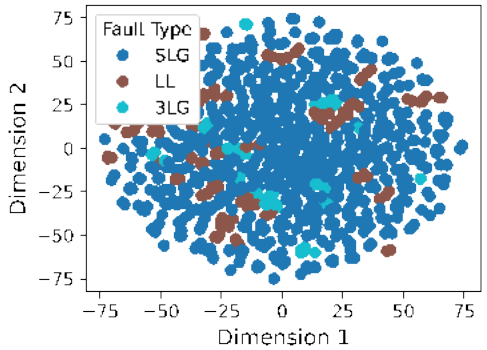
- Features: Sequence Current (I_0,I_1,I_2) and Voltages (V_0,V_1,V_2)
- To avoid under- & over-fitting, performed validation analysis

- Identified where Validation score converged w/ Training
- Optimal batch training samples equal to 20,000 for three cases

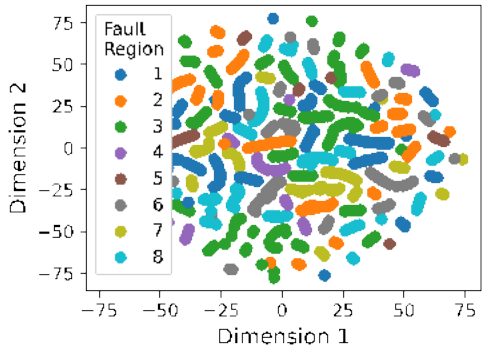
Machine Learning Breaker Analysis

- Embedded ML can
  - Classify faults
  - Identify fault regions
  - Make breaker switch decisions
- Example: ML at Breaker RTL4
  - Able to separate 6-dimensional data
  - Learn and classify accurately

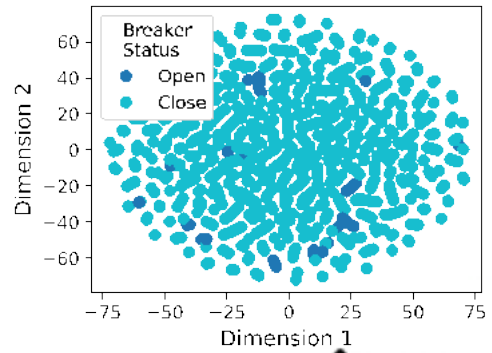




Fault Classification



Fault Region



Decision

Conclusions/Recommendations

- Conclusion:
  - SVM accurately understands fault conditions and makes breaker decisions
- Difference from Expected:
  - Better than expected:
    - Accurate classification of fault types and regions anywhere on feeder
    - Near perfect decision making
- Future Work:
  - Implement in HIL
  - Compare with existing approaches
  - Reconfiguration situational awareness