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A Comparison Study of Feature Extraction and Data Fusion Techniques for Improving Cyber-Physical Situational Awareness

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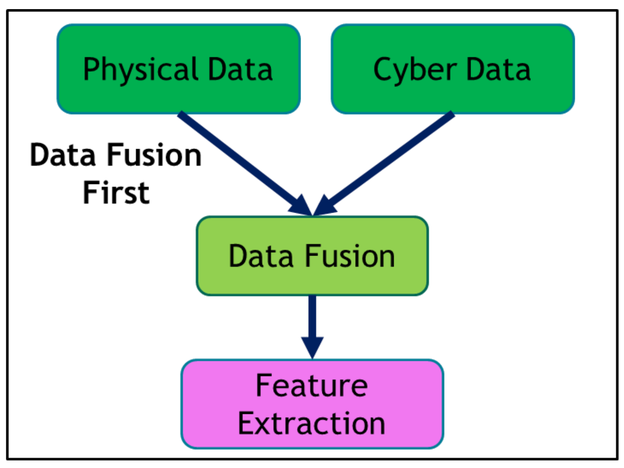
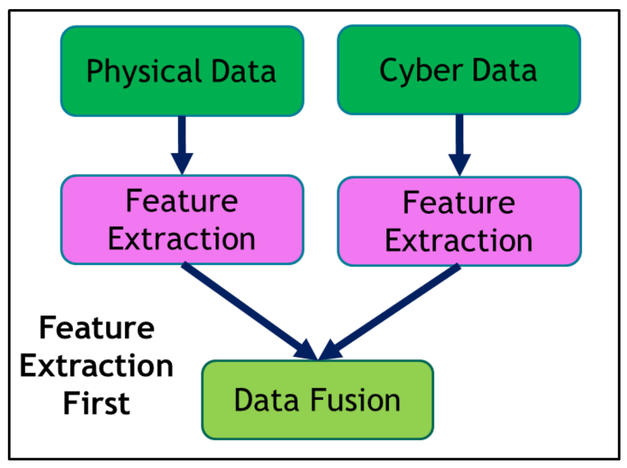
Background:

- Modern power grids are tightly integrated with communications systems and cyber networks, and this integration continues to increase as more communication-enabled devices are added
- It is no longer sufficient to independently collect and analyze physical systems data and cyber data
- Detecting modern cyber-physical attacks on the power grid requires an integrated analysis of both cyber and physical data sources





Collected Data:

- Cyber Data collected from 3 substation locations:
  - Round-trip times (RTT)
  - Packet retransmits
  - Cyber data collected at 1 sec intervals and upsampled to 33 samples per second
- Physical Data collected from 8 PMU sensors:
  - Voltage magnitude and angle
  - Current
  - Frequency
  - Physical data sampled at 33 samples per second

Scenario:

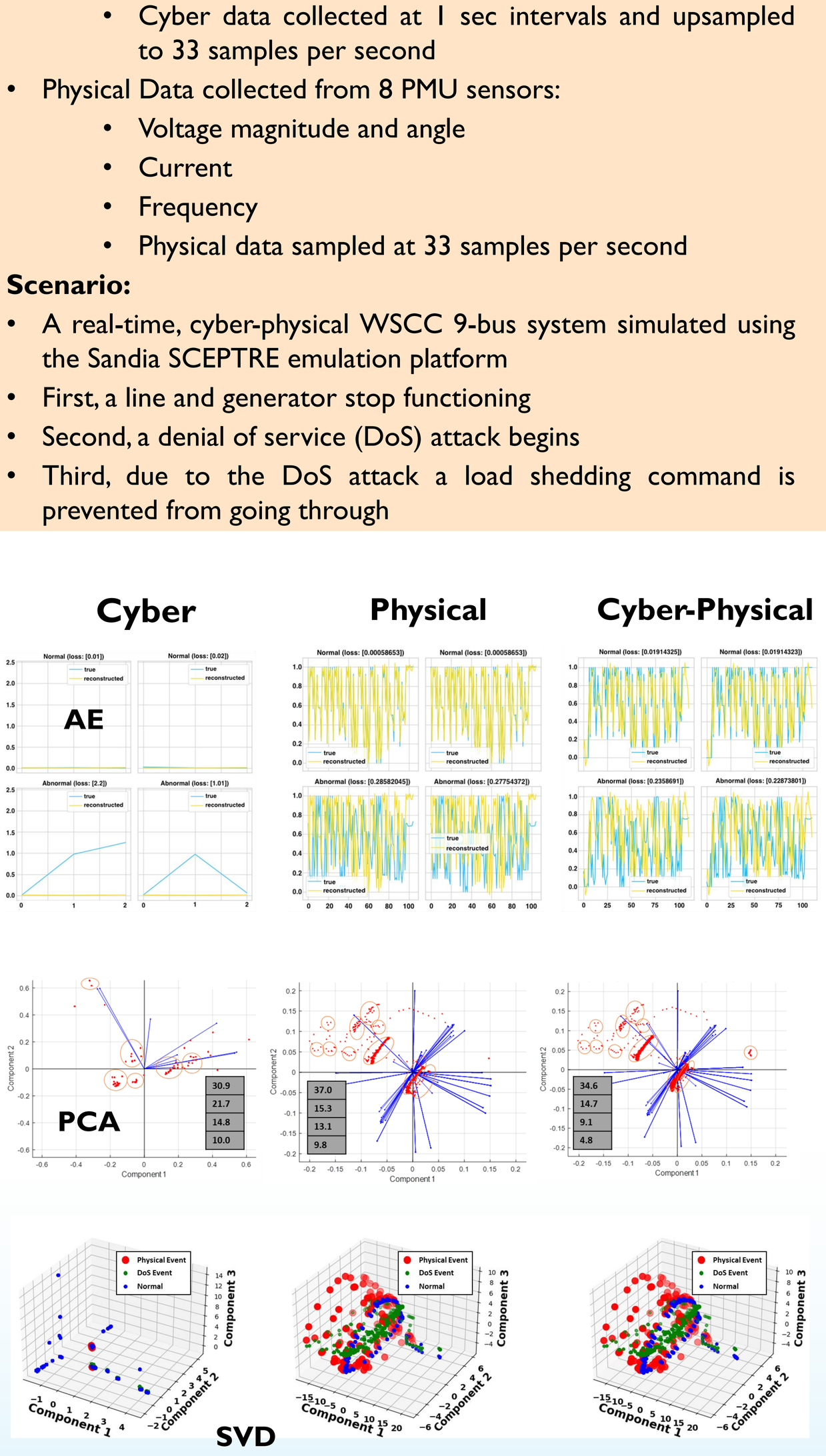
- A real-time, cyber-physical WSCC 9-bus system simulated using the Sandia SCEPTRE emulation platform
- First, a line and generator stop functioning
- Second, a denial of service (DoS) attack begins
- Third, due to the DoS attack a load shedding command is prevented from going through

Methodology:

- Tested three feature extraction methodologies:
  - Principal Component Analysis (PCA) with Singular Value Decomposition (SVD)
  - Stochastic Neighbor Embedding (t-SNE)
  - Autoencoder (AE)
- Each method was run on the cyber only, physical only, and combined cyber/physical datasets

Key Takeaways:

- Each feature extraction technique is a feasible choice for cyber-physical system analysis
- AE provides a fully unsupervised feature extraction plus anomaly detection solution
- The result plots for the physical and cyber-physical cases are nearly identical. We hypothesize that this is due to the larger number of physical features as well as the upsampling of the cyber data



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