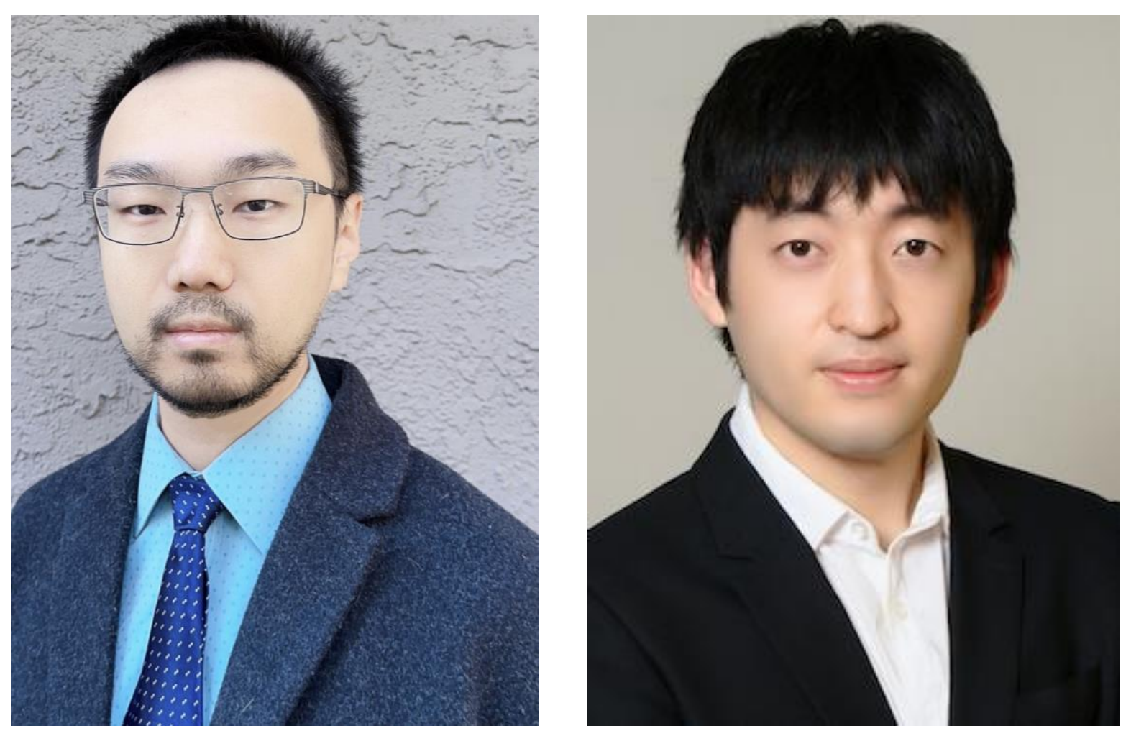
Collaborative Research: FMitF: Track I: Towards Verified Robustness and Safety in Power System-Informed Neural Networks



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This project aims to enhance the robustness and safety of neural networks in power systems by developing advanced verification methods that incorporate physical constraints, offering improved grid reliability, cybersecurity protection, and broader adoption of trustworthy AI, while fostering interdisciplinary education and diversity in STEM fields.

Challenges and Significance:

1. **Vulnerability of Neural Networks in Power Systems:** Raises safety and reliability concerns in critical systems.
2. **Lack of Formal Verification in Power System-Informed Neural Networks:** Hinders safe adoption of NNs due to potential catastrophic failures.
3. **Challenges of Incorporating Physical Constraints in NN Verification:** Critical for ensuring accurate, law-abiding network operations.

Scientific Impact:

1. **Formal Neural Network Verification**: Methods developed for NN robustness verification can be applied to safety-critical domains like healthcare, finance, and autonomous systems.
2. **Integrate Physical Constraints in Formal Methods**: Approaches for incorporating real-world physical laws in verification can generalize to fields like robotics, aerodynamics, and material sciences.
3. **Scalability and Efficiency in Verification Tools**: GPU-accelerated, scalable verification tools can benefit other fields needing large-scale system verification

Solution:

1. **Neural Network Verification**: Introduces efficient, GPU-accelerated verification (α,β-CROWN)
2. **Power System Constraints**: Integrates physical laws into NN verification
3. **Certifiable Training**: Improved certifiable training to boost robustness
4. **Topology-Aware Networks**: Introduce topology-aware networks to capture the structure of power grids and enhance robustness in tasks like fault localization.
5. **Sensitivity Analysis**: Develops formal method-boosted sensitivity analysis for better power system planning decisions.

Society Impact

1. Improved Power Grid Reliability
2. Advances in Trustworthy AI
3. Energy Security and Stability
4. Resilience Against Cyber Threats
5. Public Infrastructure Security

Education Impact and Outreach

1. Integration of Formal Methods in Graduate Courses
2. Student Training and Mentorship
3. Workshops and Conferences
4. IEEE Mentoring Program

Broader Impact

1. Engages high school students through lab tours
2. Reduces costs and prevents financial losses associated with power system failures
3. Actively recruits and mentors underrepresented groups in STEM, fostering inclusion.