VU-ANH LE

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RESEARCH INTERESTS

My research focuses on developing reliable and explainable AI models and applying them to climate science. Drawing on techniques from applied topology, graph theory, and statistics, I investigate the structural properties that ensure robustness, scalability, and efficiency in machine learning systems. I then translate these theoretical results into designing explainable AI models that help climate scientists predict natural hazards and strengthen community resilience, particularly in coastal regions.

EDUCATION

Beloit College Beloit, Wisconsin
Bachelor of Science, Mathematics, GPA: 3.58/4.00 *Aug 2021 - May 2025*
Relevant Coursework: Mathematical Statistics, Differential Equations, Complex Analysis, Topology, Algorithm Design and Analysis, Data Mining

SELECTED RESEARCH EXPERIENCES

Vietnam Academy of Science and Technology Hanoi, Vietnam
Researcher, Institute of Information Technology *June 2023 – Present*

- Proved eigenvalue-level robustness for persistent Laplacians: a uniform Lipschitz bound showing any single up-persistent Laplacian eigenvalue shifts by at most $2\|\partial\sigma\|_2^2$ under one-simplex insertion. This result closes an open gap in spectral Topological Data Analysis (TDA) stability and enables error control for spectral features in dynamic complexes.
- Designed a boundary-weighted graph filter for δ-hyperbolic graphs using Busemann functions; established a closed-form spectral-norm contraction (curvature-controlled energy decay per pass), giving a lightweight, parameter-free stability mechanism for hierarchical networks.
- Co-designed **Residual Noise-Fingerprinting (RN-F)**, a residual-noise fingerprinting framework for Large Language Models' contamination detection that operates in a semi–black-box regime via layer-wise FP16–INT4 activation residuals; provided distributional guarantees and single-pass detection with minimal compute.
- Developed spectral–topological operators for graphs and complexes: Lipschitz-stable persistent spectra for robust feature extraction; curvature-aware filters for message passing; and theory-driven constraints for safe graph pipelines in foundation model pretraining.
- Results include two arXiv preprints on graph spectral stability and hyperbolic filtering; one *ICML 2025 DIG-BUGS workshop* paper on contamination detection; one *Maltepe Journal of Mathematics* article on topology-preserving scaling for augmentation.

Ministry of Agriculture and Environment Hanoi, Vietnam
Research Intern, National Remote Sensing Department *Aug 2021 – May 2025*

- Derived physics-informed convergence guarantees for neural operators solving PDEs via contraction mappings; analyzed stability regions and step-to-solution error decay under operator compositions.
- Engineered a differential-operator solver with provable exponential convergence and achieved **15% faster training** than DeepONet while maintaining reliability bounds (theory-first design; ablations across discretizations).
- Built evaluation harnesses for stiffness regimes and boundary conditions; profiled compute/performance trade-offs for mixed-precision inference on sequence-to-operator workloads.
- Published journal article formalizing scaling-robust augmentation with optimization over Δs under a TDA stability constraint; two papers published in *Maltepe Journal of Mathematics* and Chapter 23 in the book issue *Advances in Quantum Calculus and Functional Analysis, CRC Press.*