



# Ibrahim ALJabea, PhD candidate

*Topological Deep Learning, Higher-Order Neural Networks, and Dynamical Systems*

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## Objective

- To secure a challenging position in a reputable company where I can leverage my problem-solving skills, expand my expertise, and contribute meaningfully to the company's success.

## Education

2019 – now **Ph.D in Mathematics**, *Louisiana State University (LSU)*.

2022 – now **Graduate Minor in Computer Science and Engineering**, *LSU*.

2015 – 2018 **M.S. in Mathematics**, *Memorial University of Newfoundland (MUN), Canada*.

2005 – 2008 **M.S. in Mathematics**, *Jordan University of Science and Technology, Jordan*.

## Research Experience (Projects)

- To access my research statement, please click [here](#).
- 1- TopoX: Developer of three transformative Python packages for Topological Deep Learning, designed to enable fast and robust deep learning computations for graph generalizations, including hypergraphs, simplicial complexes, and cellular complexes. Explore the packages on GitHub: <https://github.com/pyt-team>.
- 2- Approximations of Koopman Operator Semigroups. In progress.
- 3- Deep Learning Approach for Frog Egg Qualification: This project was a collaboration between the Mathematics Department at LSU and the AGGRC (Aquaculture Genetics and Genomics Research Center), <https://aggrc.com/>. The primary goal was to develop a new model based on the Stardist machine learning package, which uses image segmentation and star-convex polygons to count eggs by detecting cell nuclei.
- 4- Topological Representation Learning: The purpose of this project is to investigate methods for topological representation learning in *TopoEmbedX* (TEX) and explore how it can be applied to represent elements of a topological domain within a Euclidean space.

## Open Source

2022 - now *TopoNetX* (TNX), Developer.

- A Python package for modeling entities and relationships in higher-order networks, such as meshes and simplicial complexes.

2022 - now *TopoModelX* (TMX), Developer.

- A Python package designed for efficient deep learning models on topological domains, such as simplicial and cell complexes.

2022 - now [TopoEmbedX](#) (TEX), Developer.

- A Python package for efficient representation learning on relational systems within topological domains, such as social networks and protein structures.

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## Conferences and Workshops

- **Society for Industrial and Applied Mathematics (SIAM)**, *Conference on Mathematics of Data Science (MDS24)*, Oct 20-25, 2024.

I presented my recent work on the forthcoming article, Introduction to Topological Neural Networks, along with the accompanying Python package, TopoX.

- **Neural Information Processing Systems (NeurIPS)**, *Dec 11-16, 2023*.

I participated in the NeurReps workshop on Symmetry and Geometry in Neural Representations <https://www.neurreps.org/about>, where we presented our work on Topological Deep Learning and the TopoX package.

- **SIAM**, *The 6th Annual Meeting of the SIAM Texas Louisiana Section*, Nov 3-5, 2023.

- **Summer School in Mathematics of Machine Learning**, *Mathematical Sciences Research Institute (MSRI)*, Jul 25 - Aug 5, 2022.

This summer school is offered in partnership with the Istituto Nazionale di Alta Matematica Francesco Severi (INdAM) and the Courant Institute of Mathematical Sciences. Its purpose is to introduce graduate students to foundational results in deep learning techniques, with applications spanning vision, natural language processing, and reinforcement learning.

- **IMA Math-to-Industry Boot Camp participant**, *University of Minnesota*, Jun 20 – Jul 29, 2022.

This Boot Camp consisted of two parts: (i) completing courses in Applied Statistics, Data Science, Machine Learning, Optimization, and Stochastic Modeling, and (ii) collaborating with a team under the guidance of a data scientist at C.H. Robinson to analyze customer quote selection and pricing strategies. Our project began with a dataset of approximately 400,000 quote entries from C.H. Robinson's website, which required extensive data cleaning and preprocessing. Using a variety of machine learning models, including XGBoost, CatBoost, KNN, and Neural Networks, we worked to predict customer quote preferences. These models were crucial for constructing yield surfaces, allowing us to develop optimal pricing strategies aimed at maximizing the company's expected value (EV) of profit, <https://cse.umn.edu/ima/events/math-industry-boot-camp-vii>.

- **4th LBRN-LONI Scientific Computing Bootcamp**, *High Performance Computing, LSU*, May 2021.
- **19th Annual Aldrich Multidisciplinary**, *Graduate Research Conference*, Mar 2017.
- **Student Leadership Conference**, *MUN*, Jan 2017.

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## Publications

- 1- **TopoX**: A Suite of Python Packages for Machine Learning on Topological Domains. Accepted to Journal of Machine Learning Research (JMLR).
- 2- Introduction to Topological Neural Network. In preparation.
- 3- A User's Guide to Topological Deep Learning. In preparation.
- 4- Splitting Operator Method of Lie-Koopman Operator: Analysis, Learning. In preparation.
- 5- Cohomology of GKM-sheaves. Preprint, <https://arxiv.org/abs/1806.01761>

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## Skills and Qualification

- Developer of three transformative Python packages in the area of topological deep learning: TopoNetX, TopoModelX, and TopoEmbedX.
- Experienced in collaborating with researchers of varying expertise and effectively communicating complex research concepts to diverse audiences and large groups.
- Strong teamwork skills and a willingness to contribute to various committees and groups.
- Able to quickly understand and explain complex ideas.

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## Programming Experience

- **Programming Languages:** Python, C# Programming,  $\LaTeX$  and Beamer.
- **Tools:** Tensorflow, Pytorch, Geometric Pytorch, scikit-learn, NetworkX, Numpy, Scipy, TopoModelX, TopoNetX, TopoEmbedX, Git.

## Certificates and Achievements

- **IBM Data Science**, *LSU Degree and Certificate Students Academy, 2024 In progress.*
- **Graph Neural Network**, *LSU, 2023.*
- **Machine Learning and Deep Learning**, *LSU, 2023.*
- **Training course in Python and R programming**, *LSU, 2021.*
- **Improving Deep Neural Networks: Hyperparameters Tuning, Regularization and Optimization**, *Coursera, 2021.*

## Work Experience

2019 - present **Research and Teaching Assistant**, *LSU.*

- Research in Higher Order Neural Networks, dynamics and teaching MATH 1550 (Calculus I) MATH 1020/1021 (College Algebra), and 1552 (Calculus II).

2013 - 2018 **Research Assistant Memorial University**, *MUN.*

## Leadership, Services and Volunteering

2023 Organization committee for the student colloquium, *Department of Mathematics, LSU.*

2023 Mentor (senior researcher), *SIAM TX-LA 2023 SIAM Texas-Louisiana Sectional Meeting.*

Fall 2023 Volunteered for a capstone course project in machine learning, *Department of Mathematics, LSU.*

## Talks

- 1- Topological Neural Networks, *SIAM Conference on Mathematics of Data Science (MDS24), October 2024.*
- 1- Koopman Operator and Approximation of Semigroups by Using Splitting Methods, *LSU, April 2023.*
- 2- Morse Theory, *LSU, May 2020.*
- 3- Equivariant Cohomology and Fibre Bundles, *MUN, Jan 2018.*

## Memberships

2021 - present SIAM.

2019 - present American Mathematical Society (AMS).

## References

- 1- Dr. Frank Neubrander (Advisor), *LSU, Department of Mathematics*, [neubrand@math.lsu.edu](mailto:neubrand@math.lsu.edu)
- 2- Dr. Mustafa Hajij (Advisor), *USFCA, Department of Computer Science*, [mhajij@usfca.edu](mailto:mhajij@usfca.edu)
- 3- Dr. James Oxley, *LSU, Department of Mathematics*, [oxley@math.lsu.edu](mailto:oxley@math.lsu.edu)