# Elias Firisa

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*Research Interests: Generative modeling theory (flow-matching, diffusion), computational neuroscience, variational inference*

## Education

**Korea Advanced Institute of Science and Technology (KAIST)** Feb 2022 – June 2026 (Expected)
B.S. in Brain & Cognitive Sciences, Minor in Industrial & Systems Engineering Daejeon, South Korea

**Selected Coursework:** Diffusion & Flow Models, Statistical Machine Learning, Stochastic Modeling, Theoretical Neuroscience, Systems Neuroscience, Signals & Systems, Probability & Statistics, Linear Algebra, Cognitive Neuroscience, Signal-Processing.

## Blogs & Preprints

**Elias Firisa.** *Probabilistic Invertibility of Rectified Flows Beyond Global Monotonicity.* In preparation, 2026.
[Paper]

- Developed a generic-in-time invertibility theory for rectified flow maps via a transversality argument, replacing the standard global monotonicity assumption with an almost-sure injectivity guarantee under Gaussian initialization.

**Elias Firisa.** *Least Squares and Likelihood in Linear Regression.* Blog post, 2025.
[Post]

## Experience

**Generative Modeling Research Intern — *U-AIM Lab, KAIST*** *Codebase* Sept 2025 – Present

- Studying how noise schedules, guidance, and vector field geometry in flow-matching models affect ODE smoothness, few-step sampling, and generalization.
- Investigating latent structure under flow-matching objectives, specifically how vector field curvature shapes what the model learns.

**Research Intern — *Decision Brain Dynamics Lab, KAIST*** Dec 2024 – June 2025

- Processed multichannel frontal EEG signals to extract spectral biomarkers (specifically Alpha-Beta power asymmetry) indicative of acute stress responses.
- Developed machine learning pipelines to classify stress states from physiological data, analyzing feature importance to identify robust neural indicators across different subjects.

**Research Intern — *Leeds WormLab, University of Leeds*** June 2024 – Aug 2024

- Validated the efficacy of simple linear baselines (DLinear) on nonlinear chaotic systems (Duffing oscillator), characterizing generalization limits across stable versus chaotic attractor regimes.
- Extended this framework to *C. elegans* neural recordings, investigating whether simple linear approximations could recover low-dimensional manifolds governing high-dimensional population activity.

**Undergraduate Researcher — *Brain-Machine Intelligence Lab, KAIST*** *Codebase* Feb 2024 – Nov 2024

- Investigated predictive-coding–inspired objectives within Variational Autoencoders (VAEs) to model hierarchical inference, motivated by the Bayesian Brain hypothesis.
- Conducted rigorous disentanglement analysis on the CelebA dataset, utilizing latent traversals and directional edits to quantify how well the model separated distinct semantic factors (pose, lighting).

## Industry Experience

**ML Engineer (Part-time) — *Sai Technologies*** Sep 2025 – Present

- **Edge Computing Optimization:** Engineered real-time computer vision pipelines (YOLOv8, ByteTrack) on resource-constrained hardware (NVIDIA Jetson), utilizing quantization and model pruning to maximize inference throughput.
- **Interaction Tracking:** Implemented multi-object tracking algorithms to analyze temporal human–object interaction dynamics from continuous video streams.

**ML Engineer Intern — *MolpaxBio*** June 2025 – Sep 2025

- **3D Reconstruction Pipeline:** Developed a deep-learning framework to synthesize textured 3D face meshes from multimodal inputs (volumetric CT scans and 2D images) for surgical simulation.
- **Parametric Modeling:** Utilized FLAME topology to infer latent shape and expression parameters, ensuring topological consistency (watertight meshes) for downstream AI-driven manipulation.

## Selected Technical Projects

**Computational Biology & Theoretical Neuroscience** 2023–2024
*[Math-Modeling Code]* · *[Neuro-Sim Code]*

- **Dynamical Systems & Plasticity:** Modeled nonlinear biological rhythms (Circadian clocks, Calcium) and synaptic learning rules (STDP); solved inverse problems for Lotka–Volterra systems using global optimization (Simulated Annealing).
- **Statistical & Genomic Analysis:** Applied survival analysis (Cox PH) to Glioblastoma outcomes and dimensionality reduction (UMAP, t-SNE) to single-cell RNA-seq data to identify latent biological clusters.
- **Neural Coding Theory:** Quantified information content in Poisson spike trains using entropy/Fano factor analysis and reconstructed visual receptive fields via reverse correlation (Gabor filters).

**RAG System for Financial Q&A (NLP)** 2024

- **Retrieval Pipeline:** Engineered a Retrieval-Augmented Generation (RAG) system, utilizing hybrid ranking (dense + sparse vectors) to ground LLM responses in unstructured financial data.

## Teaching & Leadership

**Undergraduate Tutor — *KAIST Education Support Team*** Sept 2024 – Present

- **Academic Mentorship:** Selected to instruct undergraduates in quantitative disciplines (Linear Algebra, Probability) and core life sciences (General Biology, Systems Neuroscience), facilitating weekly review sessions and 1-on-1 coaching.

**Community Leadership** 2022 – Present

- **Head of Ethiopian Students Association (3 Years):** Led academic support and cultural integration initiatives for the Ethiopian student community at KAIST.
- **Founding Member (ASCEND KAIST):** Established and managed the Futsal division, organizing semester-long leagues to foster student wellness and cross-cultural engagement.

## Skills

**Mathematical Foundations:** Stochastic Calculus (SDEs/ODEs), Probabilistic Models, Linear Algebra
**Machine Learning:** Diffusion & Flow-Matching, Variational Inference (VAEs), Dimensionality Reduction (UMAP/t-SNE)
**Neuroscience Methods:** Neural Population Dynamics, EEG Spectral Analysis, Synaptic Plasticity (STDP)
**Languages & Tools:** Python (PyTorch, NumPy,Pandas), MATLAB, NVIDIA Jetson, Git, Docker

## Honors & Awards

**KAIST Scholarship** (Full Tuition & Monthly Stipend) 2022 – Present
**KAIST Alumni Scholarship** (Awarded for Academic Excellence) 2024
**INSEO Engineering Scholarship** (External Merit Scholarship) 2023
**1st Place — Web3 Blockchain Competition** (Decentralized Marketplace Track) 2023