# About Me



NAME

## Kai-Sheng Song

TITLE

Professor of Statistics

Department of Data Analytics and Statistics

YEARS AT UNT

19 years

RESEARCH FOCUS AREAS

- **Stochastic Processes, Statistical Learning & Signal Quantization**
- Interdisciplinary statistical research bridging theoretical stochastic modeling, actuarial mathematics, high-dimensional inference, compositional data analysis, and optimal quantization methods for image, video, and machine learning applications.

- **Stochastic Processes, Option Pricing & Actuarial Science**

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|---|---|
| **Hawkes Processes:** Statistical inference for oscillatory Hawkes point processes in high-frequency financial data (T. Bhatt, 2026). | **General Bühlmann Credibility:** Unified Bayesian approach to actuarial credibility theory for experience rating (Y. Yan, 2017). |
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| **Jump-Diffusion Classes:** Option pricing under new jump-diffusion process classes (U. Adiele, 2023). | **Insurance Risk Analytics:** Predictive premium modeling balancing individual claim history against collective pool risks. |
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| **Ornstein-Uhlenbeck:** Optimal pair-trading rules derived for non-linear boundary crossings (E. Tamakloe, 2021). | **General Optimal Method:** Optimally weighted linear combination of Bayesian linear and non-linear credibility estimators for heavy-tailed loss distributions. |
| **Stochastic Volatility:** Option Pricing frameworks utilizing observables as direct volatility proxies (J. Zhou, 2021). | |

# • High-Dimensional & Compositional Statistics

**Compositional Data & Structural Zeros**

**PLNS Framework:** Introduced Projected Log-Normal Simplex (PLNS) model for high-dimensional compositional data.

**Structural Zero Handling:** Rigorous mathematical handling of true zero proportions in constrained simplex spaces.

**Corporate Finance and Consumer Behavior Applications:** Applied to corporate debt compositions with complex structural zero patterns and consumer spending analysis.

AI Applications: Zero weights between distant or irrelevant tokens in sparse attention mechanisms (Transformers).

**Large Matrix Estimation & Mixture Models**

**Covariance & Precision Matrices:** Novel two-stage adaptive method for estimating large matrices (R. Rajendran, 2019).

**Modified EM Algorithms:** Scale-invariant equations for two-component mixture models (I. Ukenazor, 2024).

**Cubic Variance Function (CVF) & NEF-QVF Variance:** Simultaneous estimation of CVF means and natural exponential family variance functions (Z. Khan, 2025).

- # Quantization, Signal Processing & Active Research

| Image/Video Quantization & LLMs | Spatial Models & Current Ph.D. Students |
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| **"Optimal Scale-Equivariant Estimation and Robust Analytical Lloyd-Max Centroid Reconstruction" IEEE TIP Revision 2026.**<br><br>**JPEG Compression:** Robust analytical centroid reconstruction improving standard quantization loss.<br><br>**Video Compression Extension:** Inter-frame residual quantization for dynamic video stream encoding.<br><br>**LLM Quantization Extension:** Ultra-low bit weight quantization for efficient neural network compression. | **Spatial Fingerprint Spectral Analysis:** Global spatial models for loop pattern fingerprints (D. Wu, 2019).<br><br>**Kalman Filtering (Current Student):** Adaptive filtering frameworks for dynamic tracking and state estimation.<br><br>**Frequency Estimation (Current Student):** High-resolution spectral frequency extraction in noisy time-series signals. |

- **Summary of Doctoral Advising (2017–2026)**

| Graduate | Defended | Dissertation Title | Research Domain |
|---|---|---|---|
| **Tekendra Bhatt** | Mar 25, 2026 | Statistical Inference for Oscillatory Hawkes... | **High-Frequency Data Analysis** |
| **Zubair Khan** | Jul 25, 2025 | Novel Simultaneous Estimation of CVF ... | **Cubic Variance Functions** |
| **Ifeanyichukwu Ukenazor** | Jun 21, 2024 | Scale Invariant Equations ... | **Mixture Models** |
| **Ugochukwu O. Adiele** | Oct 30, 2023 | Option Pricing Under New Classes of Jump... | **Jump-Diffusion Processes** |
| **Emmanuel Tamakloe** | Jul 29, 2021 | Optimal Pair-Trading Decision Rules ... | **Stochastic Optimal Pair-Trading** |
| **Jie Zhou** | Aug 5, 2021 | New Class of Stochastic Volatility... | **Stochastic Volatility** |
| **Rajanikanth Rajendran** | Jun 28, 2019 | Two-Stage Adaptive Method... | **High-Dimensional Statistics** |
| **Di Wu** | Jun 28, 2019 | Global Spatial Model for Loop Pattern... | **Spatial Signal Processing** |