DANH-TAI HOANG, PhD

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QUALIFICATIONS

10 years in Linux OS with Command Line and Bash Scripting.

10 years in Coding with multiple programming languages (Python, Fortran, CUDA).

10 years in High-Performance Computing.

10 years in Statistical and Mathematical Modeling.

10 years in Optimizing Methods such as Markov chain Monte Carlo, Likelihood Maximization, Expectation Maximization, and Gradient Descent.

7 years in Quantitative Analysis with large data sets in various areas (Physics, Biology, Finance).

5 years in Stochastic Dynamical Systems and Time-series Analysis.

4 years in Parameter Estimations, Predictive Models, and Machine Learning algorithms (Linear Regression, Logistic Regression, K-means, Decision Tree, Random Forest, Naïve Bayes).

EDUCATION

January 2013: Ph.D. degree with highest honor in Theoretical Physics.
Laboratory for Theoretical Physics and Modeling, French National Center for Scientific Research (CNRS) – UMR 8089, and University of Cergy-Pontoise, France.

PROFESSIONAL EXPERIENCE

• **April 2016-Present: National Institutes of Health, Bethesda, Maryland, USA.**
Postdoctoral Researcher in Data Science and Machine Learning

Main research subject: *Model Selection in Stochastic Processes*

- Developed a data-driven approach, Free Energy Minimization, for causal inference in stochastic processes that works well even in the limit of small sample sizes. Besides the better performance than the present state-of-the-art methods, my approach is model-free, and does not assume any specific functional form for the interaction, allowing a systematic expansion to obtain higher-order interactions as warranted, 100 times faster than traditional methods using Maximum Likelihood Estimation (MLE) based on gradient ascent method, and generalizes to many data types.

- Inferred a currency network from currency exchange rate fluctuations, suggested a currency trading strategy which produced a profit of 150% over 14 years.

- Developed a data-driven inference of hidden nodes in networks, combining Free Energy Minimization and Expectation Maximization. This work was motivated by the fact that real-world data often contains only subsets of variables. For example, it is hopeless to obtain simultaneous spiking activity of every neuron in the brain, the transcription of every gene in the genome, every fluctuating factor in a financial system. My method with hidden nodes outperforms other existing methods with or without hidden nodes.

- Inferred a stock-market network using data of opening and closing stock prices of 25 American companies, and suggested an investment strategy which produced a profit of 350% over 10 years.

- Inferred a neuronal network from neuron activities in the salamander retina. Predicted activities of neurons from activities of input neurons with an accuracy of 80%.

- Developed a new algorithm for unsupervised data clustering, applied to classify the MNIST hand-written digit images successfully, and showed that there were about 60 clusters which are roughly equally distributed among the digits.

- Developed a data-driven approach, Expectation Reflection, to infer the residue interactions in protein sequences, applied to predict the tertiary structures of protein from multiple sequence alignments. The method provided a good inference accuracy for many protein domains.

- Build a python package for diabetes diagnose and showed that the performance of my method out-performs other traditional machine learning methods such as Logistic Regression, Naïve Bayes, and Random Forest.

• **January 2013-March 2016: Asia Pacific Center for Theoretical Physics, POSTECH, S. Korea. Postdoctoral Researcher** in Quantitative Biology, Biophysics, and Statistical Physics

Main research subject: *Design Principles of Pancreatic Islets*

- Explored the controllability of phase coordination between insulin and glucagon in Pancreatic islets (the micro-organ for controlling glucose levels). Found that this controllability is based on the interaction motif of three cell types within an islet: alpha cells activate beta and delta cells; delta cells suppress alpha and beta cells; while beta cells suppress alpha cells but activate delta cells. This particular motif is unique for requiring minimal hormone secretion and reducing glucose fluctuations.

- Introduced a mathematical model of synchronization of hormone pulses within pancreatic islets. Found that: At low glucose conditions, when alpha cells are active, every islet cell was synchronized in phase; At high glucose conditions, when betta cells are active, beta cells and alpha cells were separately synchronized, and their insulin and glucagon pulses from the two populations were out of phase; At normal glucose conditions, when alpha and beta cells are equally active, islet cells were desynchronized. The synchronization at hypoglycemia/hyperglycemia implies concentrated hormone pulses from individual cells, which may effectively increase/decrease glucose levels. In contrast, the incoherent state can effectively hide unnecessary hormone actions at euglycemia. This finding suggested the controllable synchronization of islet cells.

- Examined how the controllable synchronization is perturbed under human diabetes. Found that there was a drastic change in the out-of-phase coordination of insulin and glucagon when approximately 50% of the β cells were death which indicates becoming diabetes. Suggested new method for the diabetes diagnosis based on measuring the synchronization between hormone pulses.

- Examined the effect of re-organization of islet cells where the death beta cells are removed and replaced by other cells. Found that the cellular re-organization could actively contribute to recovery under diabetic conditions.

- Explored the role of pancreatic delta cells that delta cells enhanced the incoherent state at euglycemia.

- Investigated that the organizations and paracrine interactions of islet cells are designed for smooth transitions between synchronous and asynchronous hormone pulses, suggested new perspectives for the therapy of diabetes with an optimal structure of artificial islets made by stem cells.

GRANTS

2013-2016	National Research Foundation of Korea
2010-2012	France-Poland International Program: Hubert Curien Partnership (University of Cergy-Pontoise and Adam Mickiewicz University)

SOFTWARE DEVELOPMENT

1. Python package for network inference in stochastics systems:
https://danhtaihoang.github.io/network-inference

2. Python package for model inference with hidden variables:
https://danhtaihoang.github.io/hidden-variable

3. Python package for inferring network of residue interactions from protein sequence alignments:
https://github.com/danhtaihoang/protein-structure-inference

Other programming codes are available at https://github.com/danhtaihoang

SELECTED PUBLICATIONS (ISI JOURNALS)

20. Danh-Tai Hoang, Joseph McKenna, Chris Yang, and Vipul Periwal, *Data-driven approach for inferring residue interactions in protein sequences*, in preparation.

19. Danh-Tai Hoang, Junghyo Jo, and Vipul Periwal, *Data-driven inference of hidden nodes in networks*, Physical Review E, 99, 042114 (2019) **(Editors' Suggestion).**

18. Danh-Tai Hoang, Juyong Song, Vipul Periwal, and Junghyo Jo, *Network inference in stochastic systems from neurons to currencies: Improved performance at small sample size*, Physical Review E, 99, 023311 (2019).

17. Dong-Ho Park, Taegeun Song, Danh-Tai Hoang, Jin Xu, and Junghyo Jo, *A Local Counter-regulatory motif modulates the global phase of hormonal oscillations*, Nature-Scientific Reports, 7, 1602 (2017).

16. Danh-Tai Hoang, Manami Hara, Junghyo Jo, *Design principles of pancreatic islets: Glucose-dependent coordination of hormone pulses*, PLOS ONE, 11(4): e0152446 (2016).

15. Danh-Tai Hoang, B. Prasanna Venkatesh, Seungju Han, Junghyo Jo, Gentaro Watanabe, Mahn-Soo Choi, *Scaling law for irreversible entropy production in critical systems*, Nature-Scientific Reports, 6, 27603 (2016).

14. Marissa Pastor, Juyong Song, Danh-Tai Hoang, Junghyo Jo, *Minimal Perceptrons for Memorizing Binary Patterns*, Physica A, 462, 31-37 (2016).

13. Danh-Tai Hoang, Junghyo Jo, Hyunsuk Hong, *Traveling wave in a three-dimensional array of conformist and contrarian oscillators*, Physical Review E, 91, 032135 (2015).

12. Danh-Tai Hoang, Hitomi Matsunari, Masaki Nagaya, Hiroshi Nagashima, J. Michael Millis, Piotr Witkowski, Vipul Periwal, Manami Hara, Junghyo Jo, *A Conserved Rule for Pancreatic Islet Organization*, PLOS ONE, 9, 10, e110384 (2014).

11. Juyong Song, Danh-Tai Hoang, Jongwook Kim, and Junghyo Jo, *Population balancing with species switching*, J. Korean Phys. Soc., 61, 1, 111-116 (2014).

10. Danh-Tai Hoang and H. T. Diep, *Phase transition in dimer liquids*, J. Phys.: Condens. Matter., 26, 035103 (2014).

9. H. T. Diep, Virgile Bocchetti, Danh-Tai Hoang, and V. T. Ngo, *Theory and simulation of magnetic material: Physics at phase frontiers*, J. Phys.: Conference Series, 537, 01200 (2014).

8. Danh-Tai Hoang, Juyong Song, and Junghyo Jo, *Partial mixing phase of binary cells in finite systems*, Physical Review E. 88, 062725 (2013).

7. Maciej Kasperski, Henryk Puszkarsi, Danh-Tai Hoang, and H. T. Diep, *Magnetic properties of two-dimensional nanodots: Ground state and phase transition*, AIP Advances, 3, 122121 (2013).

6. Danh-Tai Hoang, Maciej Kasperski, Henryk Puszkarsi, and H. T. Diep, *Re-orientation transition in molecular thin films: Potts model with dipolar interaction*, J. Phys.: Condens. Matter., 25, 056006 (2013).

5. Danh-Tai Hoang and H. T. Diep, *Effect of dipolar interaction in molecular crystals*, J. Phys.: Condens. Matter., 24, 415402 (2012).

4. Danh-Tai Hoang and H. T. Diep, *Hexagonal-close-packed lattice: Ground state and phase transition*, Physical Review E, 85, 041107 (2012).

3. H. T. Diep, Yann Magnin, and Danh-Tai Hoang, *Spin resistivity in magnetic materials*, Acta. Phys. Pol. A, 121, 985-991 (2012).

2. Danh-Tai Hoang, Yann Magnin, and H. T. Diep, *Spin resistivity in the frustrated J_1-J_2 model*, Mod. Phys. Lett. B, 25, 937-945 (2011).

1. Yann Magnin, Danh-Tai Hoang, and H. T. Diep, *Spin transport in magnetically ordered systems: Effect of the lattice relaxation time*, Mod. Phys. Lett. B, 25, 1029-1040 (2011).

CONFERENCE PRESENTATIONS

Invited

6. Danh-Tai Hoang, Junghyo Jo, and Vipul Periwal, *System inference with small sample size in stochastic systems* (keynote, presented by Vipul Periwal), NIST Workshop on Complex Systems Chemistry at the Nexus of Chaos, Emergence, and Information Theory, October 22-24, 2018, NIST, Maryland, USA.

5. Danh-Tai Hoang, Juyong Song, Vipul Periwal, and Junghyo Jo, *Causality inference in stochastic systems from neurons to currencies*: profiting from small sample size (invited, presented by Vipul Periwal), 2018 Quantitative Life Science Workshop, October 15-18, 2018, KIAS, Seoul, Korea.

4. Danh-Tai Hoang, Juyong Song, Vipul Periwal, and Junghyo Jo, *Non-equilibrium Network Reconstruction with Little Data* (invited, presented by Danh-Tai Hoang), Workshop on Push the Envelope of Statistical Physics: Econo, Social, Bio and Beyond, December 12-15, 2016, Pohang, Korea.

3. Danh-Tai Hoang, Manami Hara, and Junghyo Jo, *Cellular Organization and Controllable Synchronization of Pancreatic Islets* (invited, presented by Danh-Tai Hoang), Korean Physical Society (KPS) Fall Meeting, October 21-23, 2015, Gyeongju, Korea.

2. Danh-Tai Hoang and Junghyo Jo, *Morphogenesis in Life: Pancreatic Islets* (invited, presented by Danh-Tai Hoang), APCTP Workshop on Theoretical Physics, December 16, 2013, Pohang, Korea.

1. Yann Magnin, Danh-Tai Hoang, and H. T. Diep, *Spin Resistivity in Magnetic Materials* (invited, presented by H. T. Diep), European Conference "Physics of Magnetism 2011" (PM'11), June 27-July 1, 2011, Poznan, Poland.

Contributed

11. Danh-Tai Hoang, Junghyo Jo, and Vipul Periwal, *Data-driven inference of hidden nodes in networks*, March 19-23, 2019, Network Biology - Cold Spring Harbor Laboratory Meeting, New York City, USA.

10. Danh-Tai Hoang, Junghyo Jo, and Vipul Periwal, *Causality inference in stochastic systems: small sample sizes and hidden variables*, 12th Annual q-bio Conference, June 26-29, 2018, Rice University in Houston, TX, USA.

9. Danh-Tai Hoang, Junghyo Jo, and Vipul Periwal, *Causality inference in stochastic systems: small sample sizes and hidden variables*, NIH BioInformatics Poster day, May 22, 2018, NIH, Bethesda, Maryland, USA.

8. Danh-Tai Hoang, Juyong Song, Vipul Periwal, and Junghyo Jo, *Maximizing weighted Shannon entropy for network inference with little data*, 11th Annual q-bio Conference, July 25-28, 2017, Rutgers University, New Jersey, USA.

7. Danh-Tai Hoang, Manami Hara, and Junghyo Jo, *Cellular Organization and Controllable Synchronization of Pancreatic Islets*, APCTP 2015 Workshop on Frontiers of Physics, December 20-23, 2015, Yeosu, Korea.

6. Danh-Tai Hoang, Manami Hara, and Junghyo Jo, *Cellular Organization and Synchronization of Pancreatic Islets*, 3rd International Workshop on Theoretical and Computational Physics (IWTCP-3): Complex Systems and Interdisciplinary Physics, July 27-30, 2015, Dalat, Vietnam.

5. Danh-Tai Hoang and Junghyo Jo, *Conserved Rule for Pancreatic Islet Organization*, XXVI IUPAP Conference on Computational Physics (CCP2014), August 11-14, 2014, Boston, Massachusetts, USA.

4. Danh-Tai Hoang, Junghyo Jo, Hyunsuk Hong, *Synchronization of conformist and contrarian oscillators under pinning force*, Korean Physical Society (KPS) Spring Meeting, April 23-25, 2014, Daejeon, Korea.

3. Danh-Tai Hoang and Junghyo Jo, *Morphogenesis in Life: Pancreatic Islets*, Nurturing Connectivity: Physics and Biology, January 15-16, 2014, Pohang, Korea.

2. Danh-Tai Hoang and Junghyo Jo, *Self-organization of Pancreatic Islets*, XXV IUPAP Conference on Statistical Physics (STATPHYS25), July 22-25, 2013, Seoul, Korea.

1. Danh-Tai Hoang, Yann Magnin, and H. T. Diep, *Spin resistivity in a spin system with a strong first-order transition, International Conference on Frustrated Spin Systems*, Cold Atoms and Nanomaterials, July 14-16, 2010, Hanoi, Vietnam.