

# NGHIA HOANG

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## Profiles & Research Interest

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### 1. On-Device Personalization with Bayesian Nonparametric Federated and Meta Learning

I am interested in the problem of meta learning in practical domains where production systems hosting analytic services often require generating warm-start solution models for emerging tasks with limited data. One potential approach to address this warm-start challenge is to adopt meta learning to generate a base model that can be adapted to solve unseen tasks with minimal fine-tuning. This however requires the training processes of previous solution models of existing tasks to be synchronized. This is not possible if these models were pre-trained separately on private data owned by different parties and cannot be synchronously re-trained.

To accommodate for such scenarios, my research aims to develop a new personalized learning framework that synthesizes customized models for unseen tasks via fusion of independently pre-trained models of related tasks. One potential direction to tackle this problem is to train local models separately and treat them as observations drawn from stochastic process that defines the behaviors of a latent global model. This results in formal meta-Bayesian learning frameworks that can infer (or synthesize) a global model given observations of those local models. I coined this approach **model fusion**.

My preliminary works in this emerging area were recently published at AACL-19, ICML-19, NeurIPS-19 & ICML-20.

#### **Research Highlight:**

I and my collaborator, Patrick Jaillet (MIT), were awarded an exploratory research grant (150K USD) for **On-Device Personalization with Meta Learning** by the MIT-IBM board of directors (12/2020-12/2021)

### 2. Bayesian Optimization and Active Learning of Gaussian Processes

Another research direction that I am pursuing is Bayesian Optimization which investigates a class of gradient-free optimization algorithm to optimize non-differentiable model parameters, which aligns with the current auto ML initiative. The key idea is to learn a GP representation of the model's behaviors at different combinatoric parameter setup and leverage this information to learn an optimal set of model parameter. The key challenge is to (1) figure out which parameter queries are most informative to accurately learn the correlation between the model's behaviors at different parameter setup (which defines the GP representation), and (2) how to do that effectively in high-dimensional model space which is often the case in many practical applications. Relevant papers were published in ICML-14, AACL-16, AACL-18, ICCV-19 & NeurIPS-20.

### 3. Transferrable and Interpretable ML for Healthcare

I am also interested in application of ML to healthcare. Two important desiderata of ML models for healthcare applications are (1) transferability where knowledge learned from one domain can be transferred effectively to another and (2) interpretability via data prototyping where models whose predictions at prototypical data points are interpretable. Relevant papers were recently published in IJCAI-19, AACL-20, WWW-21.



## Research Highlight:

I and my collaborators, Douglas A. Lauffenburger (MIT) and Sara Magliacane (University of Amsterdam), were awarded an exploratory research grant (150K USD) for **Cross-Species Translation of COVID-19 Systems Serology Data for Infection and Vaccine Treatment** by the MIT-IBM board of directors (12/2020-12/2021)

My recent work on discovering explainable representation for Drug-Drug Interaction in collaboration with colleagues from Harvard, Georgia Tech and IQVIA was mentioned on MIT Tech Review and Tech Republic:

MIT Tech Review: <https://www.technologyreview.com/f/615153/ai-adverse-drug-interactions-chemistry-health-care/>

Tech Republic:

<https://www.techrepublic.com/article/ibm-unveils-new-ai-model-to-predict-potentially-harmful-drug-to-drug-interactions/>

## Educational Background

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### Doctor of Philosophy (Ph.D. in Computer Science)

[2010 – 2015]

Department of Computer Science, School of Computing (SoC), National University of Singapore (NUS)

Thesis Title: New Advances on Bayesian and Decision-Theoretic Approaches for Interactive Machine Learning.

Following my PhD, I spent the next two years working as a Research Fellow at NUS, and then Postdoctoral Research Associate at MIT. After my postdoctoral training, I joined MIT-IBM Watson AI Lab as a Research Staff Member in 2018. In 2021, I joined the Amazon AWS AI Labs as a Senior Machine Learning Scientist.

## Publications

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[1] Trong Nghia Hoang, Shenda Hong, Cao Xiao, Bryan Kian Hsiang Low and Jimeng Sun (2021), “**AID: Active Distillation Machine to Leverage Pre-Trained Black-Box Models in Private Data Settings**”. In the Proceeding of the Web Conference (**WWW-21**). [20.60% acceptance rate]

[2] Minh Hoang, Trong Nghia Hoang, Hai Pham and David Woodruff (2020), “**Revisiting the Sample Complexity of Sparse Spectrum Approximation of Gaussian Processes**”. In the Proceeding of Advances in Neural Information Processing Systems (**NeurIPS-20**). (**co-first author**) [20.06% acceptance rate]

[3] Trong Nghia Hoang, Chi Thanh Lam, Kian Hsiang Low and Patrick Jaillet (2020), “**Learning Task-Agnostic Embedding of Multiple Black-Box Experts for Multi-Task Model Fusion**”. In the Proceeding of the International Conference on Machine Learning (**ICML-20**). [21.08% acceptance rate]

[4] Cao Xiao, Trong Nghia Hoang, Shenda Hong, Tengfei Ma and Jimeng Sun (2020), “**CHEER: Rich Model Helps Poor Models via Knowledge Infusion**”. In the Proceeding of the IEEE Transaction of Knowledge and Data Engineering (**TKDE-20**). (**co-first author**)

[5] Kexin Huang, Cao Xiao, Trong Nghia Hoang, Lucas Glass and Jimeng Sun (2020), “**CASTER: Predicting Drug Interactions with Chemical Substructure Representation**”. In the Proceeding of the AAAI Conference in Artificial Intelligence (**AAAI-20**). [20.4% acceptance rate]



- [6] Mikhail Yurochkin, Mayank Argawal, Soumya Ghosh, Kristjan Greenewald and Trong Nghia Hoang (2019), **"Statistical Model Aggregation via Parameter Matching"**. In the Proceeding of Advances in Neural Information Processing Systems (**NeurIPS-19 – formerly NIPS**). [21% acceptance rate]
- [7] Pu Zhao, Sijia Liu, Pin-Yu Chen, Trong Nghia Hoang, Kaidi Xu, Bhavya Kailkhura and Xue Lin (2019), **"On the Design of Adversarial Examples by Leveraging Gradient-Free Optimization and Operator Splitting Method"**. In the Proceeding of the International Conference on Computer Vision (**ICCV-19**). [25% acceptance rate]
- [8] Quang Minh Hoang, Trong Nghia Hoang, Kian Hsiang Low and Carleton Kingsford (2019), **"Collective Model Fusion for Multiple Black-Box Experts"**. In the Proceeding of the International Conference on Machine Learning (**ICML-19**). [22.60% acceptance rate] (**co-first author**)
- [9] Mikhail Yurochkin, Mayank Argawal, Soumya Ghosh, Kristjan Greenewald, Trong Nghia Hoang and Yasaman Khazaeni (2019), **"Bayesian Nonparameteric Federated Learning for Neural Networks"**. In the Proceeding of the International Conference on Machine Learning (**ICML-19**). [22.60% acceptance rate]
- [10] Hong Shenda, Cao Xiao, Trong Nghia Hoang, Tengfei Ma, Hongyan Li and Jimeng Sun (2019), **"RDPD: Rich Data Helps Poor Data via Imitation"**. In the Proceeding of the International Joint Conference on Artificial Intelligence (**IJCAI-19**). [17.88% acceptance rate]
- [11] Tianfan Fu, Trong Nghia Hoang, Cao Xiao and Jimeng Sun (2019), **"DDL: Deep Dictionary Learning for Predictive Phenotyping"**. In the Proceeding of the International Joint Conference on Artificial Intelligence (**IJCAI-19**). [17.88% acceptance rate] (**co-first author**)
- [12] Haibin Yu, Trong Nghia Hoang, Kian Hsiang Low and Patrick Jaillet (2019), **"Stochastic Variational Inference for Bayesian Sparse Gaussian Process Regression"**. In the Proceeding of the International Joint Conference on Neural Networks (**IJCNN-19**).
- [13] Trong Nghia Hoang, Quang Minh Hoang, Kian Hsiang Low and Jonathan How (2019), **"Collective Online Learning via Decentralized Gaussian Processes in Massive Multi-Agent Systems"**. In the Proceeding of the 33<sup>rd</sup> AAAI Conference in Artificial Intelligence (**AAAI-19**). [16.20% acceptance rate]
- [14] Trong Nghia Hoang, Yuchen Xiao, Kavinayan Sivakumar, Christopher Amato and Jonathan How (2018), **"Near-Optimal Adversarial Policy Switching for Decentralized Asynchronous Multi-Agent Systems"**. In the Proceeding of the International Conference on Robotics and Automation (**ICRA-18**). [40.6% acceptance rate]
- [15] Trong Nghia Hoang, Quang Minh Hoang, Kian Hsiang Low and Ruofei Ouyang (2018), **"Decentralized High-Dimensional Gaussian Process Optimization with Factor Graphs"**. In the Proceeding of the 32<sup>nd</sup> AAAI Conference in Artificial Intelligence (**AAAI-18**). [24.55% acceptance rate]
- [16] Yehong Zhang, Trong Nghia Hoang, Kian Hsiang Low and Mohan Kankanhalli (2017), **"Information-Based Multi-Fidelity Bayesian Optimization"**. In the Proceeding of the NIPS Workshop on Bayesian Optimization (BayesOpt-17).
- [17] Quang Minh Hoang, Trong Nghia Hoang and Kian Hsiang Low (2017), **"A Generalized Stochastic Variational Bayesian Hyperparameter Learning Framework for Sparse Spectrum Gaussian Process Regression"**. In the Proceeding of the 31<sup>st</sup> AAAI Conference in Artificial Intelligence (**AAAI-17**). [24.6% acceptance rate]
- [18] Trong Nghia Hoang, Quang Minh Hoang and Kian Hsiang Low (2016), **"A Distributed Variational Inference Framework for Unifying Parallel Sparse Gaussian Process Regression Models"**. In the Proceeding of the 33<sup>rd</sup> International Conference on Machine Learning (**ICML-16**). [24.30% acceptance rate]



- [19] Zhang Yehong, Trong Nghia Hoang, Kian Hsiang Low and Mohan Kankanhalli (2016), "**Near-Optimal Active Learning of Multi-Output Gaussian Processes**". In the Proceeding of the 30<sup>th</sup> AAAI Conference in Artificial Intelligence (**AAAI -16**). [Oral Presentation][25.75% acceptance rate]
- [20] Trong Nghia Hoang, Quang Minh Hoang and Kian Hsiang Low (2015), "**A Unifying Framework of Anytime Sparse Gaussian Process Regression Models with Stochastic Variational Inference for Big Data**". In the Proceeding of the 32<sup>nd</sup> International Conference on Machine Learning (**ICML -15**). [26.0% acceptance rate]
- [21] Trong Nghia Hoang, Kian Hsiang Low, Patrick Jaillet and Mohan Kankanhalli (2014), "**Nonmyopic  $\epsilon$ -Bayes-Optimal Active Learning of Gaussian Processes**". In the Proceeding of the 31<sup>st</sup> International Conference on Machine Learning (**ICML -14**). [Cycle 2, 25.0% acceptance rate]
- [22] Kian Hsiang Low, Jie Chen, Trong Nghia Hoang, Nuo Xu and Patrick Jaillet (2014), "**Recent Advances in Scaling up Gaussian Process Predictive Model for Large Spatiotemporal Data**". In the Proceeding of the Dynamic Data-driven Environmental Systems Science Conference (DyDESS -14).
- [23] Prabhu ,Natarajan, Trong Nghia Hoang, Yongkang Wong, Kian Hsiang Low and Mohan Kankanhalli (2014), "**Scalable Decision-Theoretic Coordination and Control for Real-time Active Multi-Camera Surveillance**". In the Proceeding of the 8<sup>th</sup> ACM/IEEE International Conference on Distributed Smart Cameras (ICDSC-14).
- [24] Trong Nghia Hoang, Kian Hsiang Low, Patrick Jaillet and Mohan Kankanhalli (2014), "**Active Learning is Planning: Nonmyopic  $\epsilon$ -Bayes-Optimal Active Learning of Gaussian Processes**". In T. Calders, F. Esposito, E. Hullermeier, R. Meo, editors, Proceedings of the 7<sup>th</sup> European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML/PKDD-14) Nectar (New Scientific and Technical Advances in Research) Track, Part III, LNCS 8726, Springer.
- [25] Trong Nghia Hoang and Kian Hsiang Low (2013), "**Towards Practical Planning to Predict and Exploit Intentions for Interacting with Self-Interested Agents**". In the Proceeding of the 23<sup>rd</sup> International Joint Conference on Artificial Intelligence (**IJCAI -13**). [Oral Presentation][13.2% acceptance rate]
- [26] Trong Nghia Hoang and Kian Hsiang Low (2013), "**A General Framework for Interacting Bayes-Optimally with Self-Interested Agents using Arbitrary Parametric Model and Model Prior**". In the Proceeding of the 23<sup>rd</sup> International Joint Conference on Artificial Intelligence (**IJCAI -13**). [28.0% acceptance rate]
- [27] Prabhu Natarajan, Trong Nghia Hoang, Kian Hsiang Low and Mohan Kankanhalli (2012), "**Decision-Theoretic Coordination and Control for Active Multi-Camera Surveillance in Uncertain, Partially Observable Environments**". In the Proceeding of the 6<sup>th</sup> ACM/IEEE International Conference on Distribute Smart Cameras (ICDSC -12).
- [28] Prabhu Natarajan, Trong Nghia Hoang, Kian Hsiang Low and Mohan Kankanhalli (2012), "**Decision-Theoretic Approach for Maximizing Observation of Multiple Targets in Multi-Camera Surveillance**". In the Proceeding of the Eleventh International Conference on Autonomous Agents and Multi-agent Systems (**AAMAS-12**). [Full Paper, Oral Presentation] [20.4% acceptance rate]
- [29] Trong Nghia Hoang and Kian Hsiang Low (2012), "**Intention-Aware Planning Under Uncertainty for Interacting with Self-Interested, Boundedly Rational Agents**". In the Proceeding of the Eleventh International Conference on Autonomous Agents and Multi-agent Systems (AAMAS-12). [Extended Abstract]



## Honors & Awards

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Dean's Graduate Research Excellent Award (NUS)	2015
Research Achievement Award x2 (NUS)	2013 – 2014
President Graduate Fellowship (NUS)	2010 – 2014

## Working Experience

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Senior Machine Learning Scientist (Amazon Research)	Nov 2020 – present
Research Staff Member (MIT-IBM Watson AI Lab, IBM Research)	Aug 2018 – Oct 2020
Postdoctoral Associate (Laboratory for Information and Decision Systems, MIT)	Apr 2017 – Feb 2018
Research Fellow (SeSaMe Centre, Interactive Digital Media Institute, NUS)	Mar 2015 – Mar 2017
Research Assistant (SeSaMe Centre, Interactive Digital Media Institute, NUS)	Jan 2014 – Feb 2015

## Teaching

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**Teaching Assistant (NUS):** CS4248 Natural Language Processing (Semester 1, 2010-2011), CS4246 AI Planning and Decision Making (Semester 1, 2011 - 2012), CS3243 Introduction to AI (Semester 2, 2012 - 2013).

**Guest Lecturer: (1) NUS** - CS4246 AI Planning and Decision Making (Semester 1, 2015 - 2016); **(2) Harvard** - Lecture on Gaussian Processes and Sparse Approximations [Host: Professor Natesh Pillai]

**Gaussian Processes: Theory & Applications** - AI Summer School in Singapore (2020)

## Talk

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### Cost Effective and Scalable Non-parametric Bayesian Machine Learning

At: Nanyang Technological University (Singapore) (Oct 2016); Microsoft Research Cambridge (UK) (Feb, 2017); University of Edinburgh (UK) (Mar, 2017); Singapore Management University (Singapore) (Nov, 2017); and IBM Thomas J. Watson Research Center (US) (Oct, 2017)

### Collective Online Learning of Gaussian Process in Large Multi-Agent System

At: University of Manchester (UK) (Jan, 2018); and ISE Department, Rutgers University (US) (Oct, 2018)

### Active Interpretation Machine for Explainable Healthcare Analytics

At: ISE Department, Rutgers University (US) (Oct, 2019)

### Gaussian Processes: Theory & Applications

At: AI Summer School in Singapore (2020)



## US Patents

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[1] A Method for Combining Pre-Trained Neural Networks into a Memory and Computation Efficient Global Model (Application Number: 16/576927) – based on publication [5] below

[2] System and Method for Model-Free Safe Symbolic Reinforcement Learning from Visual Inputs (Application Number: 16/709633)

## Research Grants

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### **[1] On-Device Personalization with Meta Learning** (with Patrick Jaillet)

The research grant (**150K**) was reviewed and approved by the MIT-IBM board of directors under the exploratory challenge theme of the MIT Quest for Intelligence. I wrote and led the research with Patrick (MIT) as the IBM PI while working at IBM. At Amazon, I remain a collaborator on the proposal.

### **[2] Cross-Species Translation of COVID-19 Systems Serology Data for Infection and Vaccine Treatment** (with Douglas A. Lauffenburger and Sara Magliacane)

The research grant (**150K**) was reviewed and approved by the MIT-IBM board of directors under the exploratory challenge theme of the MIT Quest for Intelligence. I wrote and co-led the research with Douglas (MIT) and Sara (University of Amsterdam) as the IBM PI. At Amazon, I remain a collaborator on the proposal.

## Professional Services

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**Program Committee Member:** IROS'12, IJCAI'15, NIPS'16, ICRA'16, ICRA'18, AAMAS '18, IJCAI'18, PAKDD'18, NIPS'18, AAAI'19, ICLR'19, AAMAS'19, ICML'19, NeurIPS'19, IJCAI'19, MRS'19, IJCAI'20, ICRA'20, AAAI'20, ICML'20, ICLR'20, CoRL'20, AAMAS'20, NeurIPS'20, AAAI'21, ICLR'21, ICML'21, NeurIPS'21

**Senior Program Committee Member:** IJCAI'21

**Journal Reviewer:** IEEE-RA-L (2018), Journal of Selected Topics in Signal Processing (2014-2015), T-PAMI (2019)

**Research Proposal Reviewer:** AI Singapore Research Programme (2018-2019)

**Workshop Organizer:** Practical Bayesian Methods for Big Data (2019) as part of IBM AI Research Week (2019)

<https://deeplybayesian.github.io/>