

Gang Cao

✉ [caogang1213.github.io](https://github.com/caogang1213) | [in linkedin.com/in/gangcao1213](https://www.linkedin.com/in/gangcao1213)
☎ 0064 (0)223182048 | ✉ caogang1213@gmail.com

PERSONAL SUMMARY

- PhD in Electrical Engineering, expertise in:
 - **Machine Learning:** deep learning, Bayesian learning, artificial neural network, reinforcement learning
 - **Advance and Intelligent Control:** model predictive control, adaptive control, optimal and robust control, system modelling, parameter identification, sensor fusion
 - **Numerical Optimization:** non-/convex optimization, stochastic optimization, evolutionary algorithm, dynamic programming
 - **Computer Vision:** object recognition and detection, tracking, image processing and analysis
 - **Data Mining/Pattern Recognition:** data-driven modelling and prediction, un-/supervised learning, feature engineering, data engineering
- Academic publications, technical reports, open-source algorithm projects
- Strong mathematical skills in algorithm and optimization, linear and matrix algebra, multivariate calculus, probability and statistics, signal and system

QUALIFICATION AND PROFESSIONAL DEVELOPMENT

- **Doctor of Philosophy (PhD)** in Electrical Engineering JANUARY 2013 – MARCH 2017
SCHOOL OF ENGINEERING AND ADVANCED TECHNOLOGY
MASSEY UNIVERSITY, AUCKLAND, NEW ZEALAND

Thesis Title: Gaussian Process based Model Predictive Control

Summary: With good learning and prediction abilities of machine learning, my PhD research developed a data-driven probabilistic model predictive control (MPC) approach to address the autonomous control issue of unknown dynamical systems. The proposed MPC algorithm is (1) *safe* by considering model uncertainties, (2) *stability-guaranteed* by using terminal constraints and sets, and (3) *fast* by proposing a computationally efficient optimization algorithm. The proposed machine learning based MPC is used in a hierarchical control strategy to solve the trajectory tracking problem of an unmanned quadrotor whose dynamical functions are not known. Seven international academic papers are published based on my PhD research.

- **Master of Engineering** in Control Theory & Engineering SEPTEMBER 2008 – APRIL 2011
FACULTY OF AUTOMATION AND INFORMATION ENGINEERING
XI'AN UNIVERSITY OF TECHNOLOGY, XI'AN, CHINA

Thesis Title: Research and Development of Ladle Refining Furnace Process Control System and Steel Mechanical Performance Prediction Model

Summary: This project developed a process control and data management system for the refining process in the steel-making industry. Through using AI and mathematical modelling algorithms, intelligent data-driven models are developed to predict molten steel temperature in the refining process, and final steel mechanical performance. The project won *2012 Shaanxi Province Science and Technology Award* and *2012 Science and Technology Award of Higher Education of Shaanxi*. Three academic papers are published based on this project.

- **Bachelor of Engineering** in Electrical Engineering & Automation SEPTEMBER 2004 – JUNE 2008
SCHOOL OF MECHANICAL AND ELECTRICAL ENGINEERING
XI'AN UNIVERSITY OF ARCHITECTURE & TECHNOLOGY, XI'AN, CHINA

CAREER HISTORY

- DECEMBER 2019 – NOW **Applied Research Scientist** BBC Technologies Ltd
Hamilton, New Zealand
 - AI Team Lead
 - Project and team management
 - Research and development of AI algorithms and solutions for optical sorting machines
 - Research and development of data-driven solution for packing house
 - Research resource and documentation management
 - Technical reports and presentations
 - Attending academic conference and presentation
- SEPTEMBER 2019 – DECEMBER 2019 **Research Scientist** PlantTech Research Institute
Tauranga, New Zealand
 - Agritech technology research
- AUGUST 2017 – SEPTEMBER 2019 **Artificial Intelligence Software Developer** BBC Technologies Ltd
Hamilton, New Zealand
 - AI Research Lead
 - Research and development of AI algorithms and solutions for optical sorting machines
 - Research resource and documentation management
 - Technical reports and presentations
 - Attending academic conference and presentation
- MARCH 2013 – NOVEMBER 2015 **Teaching Assistant** School of Engineering and Advanced Technology
Massey University, New Zealand
 - Teaching second-year Signals & Systems and third-year Control Engineering
 - Assistant in control theory lab course (PID control of speed motor and pendulum)
- JANUARY 2009 – JUNE 2012 **Research Assistant** School of Automation and Information Engineering,
Xi'an University of Technology, China
 - Research and development of process control and industrial automation system
 - Funding proposal, project documentation, academic publications and technical reports

RESEARCH & DEVELOPMENT EXPERIENCE

- **AI algorithm and solution for optical sorting machine** AUGUST 2017 – NOW
 - LUCaI AI Engine development, *finalist of 2020 NZ Most Innovative Hi-Tech Agritech Solution*
 - deep learning computer vision algorithms for object recognition, detection, and segmentation
 - machine learning indirect measurement algorithms in optical sorting
 - autonomous learning and optimization algorithms for online model learning and parameter tuning
 - image process and camera calibration algorithms
 - AI and machine learning based tool development
- **AI ImageData Library development** AUGUST 2017 – NOW
 - 500,000 single production images (RGB, IR, RGB-IR)
 - 100,000 hand-labeled samples
 - AI model based annotation tool development *LabelImg+*, *ClassifyImg*, *SmarterSkin*
 - ImageData library pre-processing and management pipeline and tools
 - multi-spectral image fusion algorithms
- **Machine learning intelligent control** JANUARY 2013 – JANUARY 2017
 - Probabilistic data-driven modelling algorithm of unknown dynamical using machine learning
 - Fast and stability-guaranteed probabilistic intelligent control algorithm of unknown dynamical systems using machine learning and model predictive control

- Autonomous control of quadrotors using machine learning and probabilistic MPC
- Fast linear and nonlinear optimization algorithms
- Stochastic optimization algorithms using swarm intelligence
- Trajectory tracking control of quadrotors using machine learning and probabilistic MPC
- 7 international peer-reviewed publications
- Matlab toolbox “**gpmc**”: Gaussian Process Model Predictive Control
- Matlab toolbox “**cgps**”: Convolved Gaussian Processes

• **Ladle furnace (LF) process control system**

JANUARY 2010 – SEPTEMBER 2012

- *2012 Shaanxi Provincial Science and Technology Award*
- *2012 Science and Technology Award of Higher Education of Shaanxi*
- LF process control and data management system
- Data acquisition tool using Siemens OPC server
- Mechanical performance prediction model using artificial intelligence algorithms
- Molten steel temperature prediction model using artificial intelligence algorithms
- Alloy addition prediction model using mathematical modelling algorithm
- 3 peer-reviewed publications

• **Monocrystalline refining process control system**

AUGUST 2009 – DECEMBER 2009

• **Tunnel boring machine (TBM) PLC control system upgrade**

JULY 2008 – OCTOBER 2008

COMPUTER SKILL

- PyTorch, TensorFlow, Darknet, OpenCV, Keras, TFLearn, Scikit-learn, SciPy, CUDA
- Python, Matlab, C, C++, Shell, SQL; Linux; Git, SVN; VS Code, Qt, Vim; L^AT_EX

SELECTED AWARDS

- Finalist of 2020 NZ Hi-Tech Award in Most Innovative Hi-Tech Agritech Solution (LUCAi project)
- 2018 Tomra Value In Practice (VIP) Award
- 2012 Shaanxi Provincial Science and Technology Award
- 2012 Science and Technology Award of Higher Education of Shaanxi

PEER REVIEW ACTIVITY

- Information Sciences (Since 2019)
- Electronics Letters (Since 2019)
- IET Image Processing (Since 2019)
- IET Computer Vision (Since 2019)
- IET Control Theory and Application (Since 2018)
- Journal of Intelligent and Robotic Systems (Since 2017)
- International Journal of Intelligent Systems Technologies and Applications (Since 2016)

HOBBIES AND INTERESTS

- Cycling and Running
- Drone and DonkeyCar

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- **Gang Cao**, “Gaussian Process based Model Predictive Control,” Ph.D. dissertation, Massey University, New Zealand, 2017
 - **Gang Cao**, “LF Refining Process Control System and Forecasting Model Research of Steel Mechanical Property,” Master dissertation, Xi’an University of Technology, China, 2011 [in Chinese]
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- **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Enhanced particle swarm optimization algorithms for multiple-input multiple-output system modelling using convolved Gaussian process models,” *International Journal of Intelligent Systems Technologies and Applications*, Vol. 17, No. 3, 2018 [published online]
 - **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Gaussian process model predictive control of unmanned quadrotor helicopter,” *Journal of Intelligent and Robotic Systems* Vol. 88, No. 1, 2017, pp. 147-162
 - **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Gaussian process model predictive control of unknown nonlinear systems,” *IET Control Theory & Applications* Vol. 11, No. 5, 2017, pp. 703-713
 - Qiang Li, **Gang Cao**, Jiang Li, and Ning Wang, “Process estimated temperature model of molten steel in LF based on BP neural network combined with expert system,” *Applied Mechanics and Materials*, vol.48, 2011, pp. 853-857.
 - Qiang Li, **Gang Cao**, and Zhi-Feng Gou, “Research and implementation of Level 2 process control system for LF,” *Gongye Jiare*, vol.40, 2011, pp.34-37 [in Chinese]
 - Qiang Li and **Gang Cao**, “Forecasting model for the molten steel temperature in refining furnace based on artificial neural network and expert system,” *Heavy Machinery*, vol.6, 2010, pp.22-25 [in Chinese]
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- **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Gaussian process model predictive control of unmanned quadrotors,” in *International Conference on Control, Automation and Robotics (ICCAR)*, IEEE, 28-30 April 2016, pp. 200-206
 - **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Gaussian process based model predictive control for linear time varying systems,” in *International Workshop on Advanced Motion Control (AMC Workshop)*, IEEE, 22-24 April 2016, pp. 251-256
 - **Gang Cao**, Edmund M-K Lai, and Fakhrul Alam, “Particle swarm optimization for convolved Gaussian process models,” in *International Joint Conference on Neural Networks (IJCNN)*, IEEE, 6-11 July 2014, pp.1573-1578
 - **Gang Cao** and Edmund M-K Lai, “Dependent Gaussian process models for MIMO nonlinear dynamical systems using PSO,” in *Proceedings of 20th Electronics New Zealand Conference*, 5-6 September 2013, pp.3-7
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- **Gang Cao**, “Technical report: PatchDehydration: artificial intelligence dehydrated blueberry detection model using deep learning and an edge-detection-guided maximal-rectangle boundingbox proposal algorithm,” BBC Technologies Ltd, Hamilton, New Zealand, *Tech. Rep.*, 2020
 - **Gang Cao**, “Technical report: Artificial Intelligence Blueberry’s Calyx Recognition and Detection Model using YOLO,” BBC Technologies Ltd, Hamilton, New Zealand, *Tech. Rep.*, 2018
 - **Gang Cao**, “Technical report: How to use the YOLO based calyx recognition and detection network,” BBC Technologies Ltd, Hamilton, New Zealand, *Tech. Rep.*, 2018
 - **Gang Cao**, “Technical report: Blueberry’s calyx recognition and detection using Faster R-CNN deep learning neural networks,” BBC Technologies Ltd, Hamilton, New Zealand, *Tech. Rep.*, 2017
 - **Gang Cao**, “Technical report: Deep convolutional neural networks based blueberry calyx recognition and detection,” BBC Technologies Ltd, Hamilton, New Zealand, *Tech. Rep.*, 2017
 - **Gang Cao**, “Technical report: Modelling and Control of Unmanned Quadrotor Helicopters,” Massey University, Auckland, New Zealand, *Tech. Rep.*, 2015

- **TOMRA Fresh Food AI Research**, Tomra AI meeting, Tomra Fresh Food, Hamilton, 2021
- **BBC Technologies AI Leadership Introduction**, Tomra AI meeting, BBC Technologies, Hamilton, 2020
- **Dehydrated Blueberry Recognition using Deep Learning Computer Vision**, Neural Network Compac Meeting, BBC Technologies Ltd, Hamilton, 2018
- **Artificial Intelligence for Blueberry Sorting – An Update of AI Research at BBC Technologies Ltd**, RnD Meeting Presentation, BBC Technologies Ltd, Hamilton, 2018
- **Artificial Intelligence for Fruit Sorting – A Demonstration of AI Projects at BBC Technologies Ltd**, BBC AI Demonstration Presentation, BBC Technologies Ltd, Hamilton, 2018
- **Artificial Intelligence for Sorting and Grading**, Sales Meeting Presentation, BBC Technologies Ltd, Hamilton, 2018
- **Blueberry’s Calyx Recognition and Detection Using Artificial Intelligence**, RnD Meeting Presentation, BBC Technologies Ltd, Hamilton, 2017
- **Gaussian Process Model Predictive Control of Unmanned Quadrotors**, The 2nd International Conference on Control, Automation and Robotics, Hong Kong, 2016
- **Gaussian Process based Model Predictive Control for Linear Time Varying Systems**, IEEE International Workshop on Advanced Motion Control, Auckland, 2016
- **Enhanced PSO Algorithms for CGP Model Learning**, Massey University Post Graduate Seminar, Palmerston North, 2015
- **Particle Swarm Optimization for Convolved Gaussian Process Models**, IEEE World Congress on Computational Intelligence, Beijing, 2014
- **Dependent Gaussian Process Models for MIMO Nonlinear Dynamical Systems using PSO**, NZ Electronics Conference (ENZCon), Auckland, 2013
- **LF Process Control System**, XAUT Research Seminar, Xi’an University of Technology, Xi’an, 2012