Master of Science in ARTIFICIAL INTELLIGENCE

Nurturing talents in artificial intelligence

Apply for entry in September 2023
Different types of scholarships will be offered.

Programme Features

Why this Programme

IS THE PROGRAMME FOR YOU

World-class Rankings of HKU

Top-notch Scientists in the Faculty

Eminent Subject Ranking

Quacquarelli Symonds (QS)

Times Higher Education (THE)

World-class Rankings of HKU

QS World University Rankings by Subject 2022:

#21 World Rankings 2023

#3 Asia Rankings 2022

Top-notch Scientists in the Faculty

Clarivate Analytics’ Essential Science Indicators 2021

#56 Mathematics

18% of our professoriate staff are the world’s Top 1% scholars

Interdisciplinary and well-balanced curriculum

◊ Solid training in diverse techniques used in AI from the core courses

◊ Electives over related topics from mathematics, statistics and computer science

◊ A capstone project with real-life applications

◊ Guest lectures by distinguished scholars and industry experts

◊ Internship opportunities in the AI industry and academia

Learning within and beyond AI

◊ Students will learn the AI-related applications of mathematics, statistics and computer science to solve real-life problems

◊ The theoretical elements in the curriculum will help students develop essential intellectual capacity at large

Industry connections and career prospects

◊ Teaching team has strong connections with high-tech industries in the Greater Bay Area

◊ Our graduates are expected to be well prepared for careers such as software engineers, consultants and research scientists in AI and related fields such as big data and financial technology

Programme Information

Tuition fees

Composition fee: HK$300,000*(subject to approval)

Students are required to pay Caution Money (HK$350, refundable on graduation subject to no claims being made) and Graduation Fee (HK$350)

Programme duration

Full-time: 1.5 years

Study load

Credits: 72 credits

Learning hours: 1,440 – 2,160 hours (including 240-360 hours for project and contact hours of 264-396 hours)

Class schedule

Teaching takes place mainly on weekdays. Classes may also be arranged on Saturdays if needed.

Medium of instruction

English

Scholarships

Different types of scholarships will be offered.

Where will this Programme Lead You

Transferable skills

◊ Equip students with the solid foundation in both theory and practice in artificial intelligence and the underlying mathematical and statistical tools

◊ The practical elements in the courses help students develop essential intellectual capacity and skills, including but not limited to image processing, pattern recognition, financial technology, robotics and quantum computing and so on

◊ Students will learn the applications of mathematics, statistics and computer science to decision-making and problem-solving in all organizations and enterprise within the private and public sectors

◊ Students will be able to apply the methodologies learnt ethically and effectively in different academic or professional disciplinary areas

Host

Department of Mathematics

Addressing the need for talents in the field of artificial intelligence, the Department of Mathematics is delighted to announce the launch of the new Master of Science in Artificial Intelligence programme. With contributions from the Department of Statistics & Actuarial Science and the Department of Computer Science, we adopt an interdisciplinary academic focus to make our programme a comprehensive study in artificial intelligence.

Who should Take this Programme

◊ Candidates with a bachelor’s degree with honours in subjects including but not limited to mathematics, statistics, computer science and engineering discipline

◊ University graduates and young professionals who aspire to pursue a career in this booming field

◊ Scholastically superior students to pursue further studies in the relevant fields of AI

Who should Take this Programme

Candidates with a bachelor’s degree with honours in subjects including but not limited to mathematics, statistics, computer science and engineering discipline
WHAT YOU WILL LEARN

Programme structure
Design of curriculum (72 credits)

Compulsory courses (42 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIN7001</td>
<td>Foundations of artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7011</td>
<td>Optimization in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7013</td>
<td>Numerical methods in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7017</td>
<td>Statistics in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7021</td>
<td>Applied data mining and text analytics</td>
<td>6</td>
</tr>
<tr>
<td>COMP7404</td>
<td>Computational intelligence and machine learning</td>
<td>6</td>
</tr>
<tr>
<td>DASC7606</td>
<td>Deep learning</td>
<td>6</td>
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</table>

Disciplinary electives (18 credits)

with at least 6 credits from each of the following lists

List A:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIN7014</td>
<td>Topics in advanced numerical analysis</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7015</td>
<td>Topics in artificial intelligence and machine learning</td>
<td>6</td>
</tr>
<tr>
<td>MATH7224</td>
<td>Topics in advanced probability theory</td>
<td>6</td>
</tr>
<tr>
<td>MATH7502</td>
<td>Topics in applied discrete mathematics</td>
<td>6</td>
</tr>
<tr>
<td>MATH7503</td>
<td>Topics in advanced optimization</td>
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</table>

List B:

<table>
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<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>STAT6001</td>
<td>Computational statistics and Bayesian learning</td>
<td>6</td>
</tr>
<tr>
<td>STAT6002</td>
<td>Programming for data science</td>
<td>6</td>
</tr>
<tr>
<td>STAT6029</td>
<td>Quantitative strategies and algorithmic trading</td>
<td>6</td>
</tr>
<tr>
<td>STAT8201</td>
<td>Big data analytics</td>
<td>6</td>
</tr>
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</table>

List C:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>COMP7308</td>
<td>Introduction to unmanned systems</td>
<td>6</td>
</tr>
<tr>
<td>COMP7309</td>
<td>Quantum computing and artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>COMP7409</td>
<td>Machine learning in trading and finance</td>
<td>6</td>
</tr>
<tr>
<td>COMP7502</td>
<td>Image processing and computer vision</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7007</td>
<td>Legal issues in artificial intelligence and data science</td>
<td>6</td>
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</tbody>
</table>

Capstone project (12 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>ARIN7600</td>
<td>Artificial intelligence project</td>
<td>12</td>
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</tbody>
</table>

Remarks:
1. Students who have completed the same or similar courses in their previous studies may, on submission of relevant transcripts, be permitted to select up to 18 credits of disciplinary electives from the other two lists if they are not able to find any untaken options from any one of the lists of disciplinary electives.
2. The programme structure will be reviewed from time to time and is subject to change.

Compulsory Courses

ARIN7001 Foundations of artificial intelligence
This course introduces foundational knowledge, methods and tools in mathematics, statistics and computer science for the purpose of studying and applying artificial intelligence.

ARIN7011 Optimization in artificial intelligence
This course introduces students to the topics in theory and algorithms of optimization that play important roles in artificial intelligence and machine learning. Topics include: 1) Fundamental optimization models in AI (linear programming models, integer programming models, network models, reinforcement learning and deep learning models, etc.); 2) Optimization theory in AI (optimality conditions, constraint qualification, global landscape analysis of deep neural networks, P- and NP-hard problems, approximation algorithms, preliminary graph theory, etc.); 3) Optimization algorithms in AI: (a) Classic algorithms (simplex method, interior point method, branch and bound method, cutting plane method, representative algorithms, gradient type methods, CO methods, projection methods, penalty method, Lagrange methods, quasi-Newton methods, Newton type methods), (b) Stochastic algorithms (stochastic gradient descent (SGD), stochastic coordinate descent methods, subsampled Newton, stochastic quasi-Newton), (c) Algorithms for large-scale optimization problems (Operator splitting algorithms (BCD type algorithms, ADMM, primal-dual type algorithms, etc.), centralized/decentralized algorithms, etc.). (d) Algorithms for nonconvex optimization and training deep neural networks.

ARIN7013 Numerical methods in artificial intelligence
This course introduces students to the numerical methods that are instrumental in artificial intelligence and machine learning. Topics include: 1) Notions and concepts in numerical analysis (convolution matrix (related to CNN), kernel methods, pattern analysis, direct methods for sparse matrices), 2) Numerical method for solving linear systems (Jacobi Method, Gauss-Seidel method, Cholesky decomposition, singular value decomposition (SVD), low-rank matrix approximation with applications in artificial intelligence and machine learning). 3) Principal component analysis, tensor decomposition and their applications to computer vision, image processing and artificial intelligence and machine learning in general. 4) Compute eigenvalues and eigenvectors (Rayleigh quotient, with applications in artificial intelligence and machine learning). 5) Numerical methods for ordinary differential equations (stability, convergence analysis, relation between the SGD and Euler method, using DNN to compute ODEs).

ARIN7101 Statistics in artificial intelligence
The development of artificial intelligence has revolutionized the theory and practice of statistical learning, while novel statistical learning approaches are becoming an integral part of artificial intelligence. By focusing on the interplay between statistical learning and artificial intelligence, this course reviews the main concepts underpinning classical statistical learning, studies computer-intensive methods for conducting statistical learning, and examines important issues concerning statistical learning drawn upon modern artificial intelligence technologies. Contents include classical frequentist and Bayesian inferences, resampling methods, large-scale hypothesis testing, regularization, and high-dimensional modelling.

ARIN7102 Applied data mining and text analytics
With the rapid developments in computer and data storage technologies, the fundamental paradigms of classical data analysis are mature for change. Data mining aims at automated discovery of underlying structure and patterns in large amounts of data, especially text data. This course takes a practical approach to acquaint students with the new generation of data mining tools and techniques, and show how to use them to make informed decisions. Topics include data preparation, feature selection, association rules, decision trees, bagging, random forests and gradient boosting, cluster analysis, neural networks, introduction to text mining.

COMP7404 Computational intelligence and machine learning
This course will teach a broad set of principles and tools that will provide the mathematical, algorithmic and philosophical framework for tackling problems using Artificial Intelligence (AI) and Machine Learning.
AI and ML are highly interdisciplinary fields with impact in different applications, such as biology, robotics, language, economics, and computer science. AI refers to the science and engineering of making intelligent machines, especially intelligent computer programmes, while ML is the changes in systems that perform tasks associated with AI. Ethical issues in advanced AI and how to prevent learning algorithms from acquiring morally undesirable biases will be covered. Topics may include a subset of the following: problem solving by search, heuristic (informed) search, constraint satisfaction, games, knowledge-based agents, supervised learning, unsupervised learning; learning theory, reinforcement learning and adaptive control and ethical challenges of AI and ML.

**Disciplinary Electives**

**DASC7606 Deep learning**

Machine learning is a fast-growing field in computer science and deep learning is the cutting edge technology that enables machines to learn from large-scale and complex datasets. Ethical implications of deep learning and its applications will be covered and the course will focus on how deep neural networks are applied to solve a wide range of problems in areas such as natural language processing and image processing. Other applications such as financial predictions, game playing and robotics may also be covered. Topics covered include linear and logistic regression, artificial neural networks and how to train them, recurrent neural networks, convolutional neural networks, generative models, deep reinforcement learning, and unsupervised feature learning.

**ARIN7014 Topics in advanced numerical analysis**

This course covers a selection of topics in advanced numerical analysis, which may include: 1) Krylov subspace, generalized minimal residual method (GMRES); 2) numerical (partial) differential equations; 3) stochastic methods and their applications to artificial intelligence and machine learning; 4) approximation theory, high-dimensional approximation (MC, QMC, sparse grid method); 5) Fourier analysis, wavelet analysis; 6) robust PCA and dimensional reduction methods. The selected topics may vary from year to year.

**ARIN7015 Topics in artificial intelligence and machine learning**

Selected topics in artificial intelligence that are of current interest will be discussed in this course.

**MATH7224 Topics in advanced probability theory**

Selected topics in probability theory will be discussed in this course.

**MATH7502 Topics in applied discrete mathematics**

This course aims to provide students with the opportunity to study some further topics in applied discrete mathematics. A selection of topics in discrete mathematics applied in combinatorics and optimization (such as algebraic coding theory, cryptography, discrete optimization, etc.) The selected topics may vary from year to year.

**MATH7503 Topics in advanced optimization**

A study in greater depth of some special topics in mathematical programming or optimization. It is mainly intended for students in Operations Research or related subject areas. This course covers a selection of topics which may include convex programming, nonconvex programming, saddle point problems, variational inequalities, optimization theory and algorithms suitable for applications in various areas such as machine learning, artificial intelligence, imaging and computer vision. The selected topics may vary from year to year.

**STAT6011 Computational statistics and Bayesian learning**

This course aims to give undergraduate and postgraduate students an introduction on modern computationally intensive methods in statistics. It emphasizes the role of computation as a fundamental tool of discovery in data analysis and statistical inference, and for development of statistical theory and methods. Contents include: Bayesian statistics, Markov chain Monte Carlo methods such as Gibbs sampler, Metropolis-Hastings algorithm, and data augmentation; generation of random variables using the inversion methods, rejection sampling, the sampling/importance resampling method; optimization techniques including Newton’s method, expectation-maximization (EM) algorithm and its variants, and minorization-maximization (MM) algorithm; integration including Laplace approximation, Gaussian quadrature, the importance sampling method, Monte Carlo integration, and other topics such as hidden Markov models, and Bootstrap methods. More advanced Bayesian learning methods cover approximate Bayesian computation, the Hamiltonian Monte Carlo algorithm, hierarchical models and nonparametric Bayes.
WHAT YOU WILL LEARN

Course Description

STAT7008 Programming for data science
In the big data era, it is very easy to collect huge amounts of data. Capturing and exploiting the important information contained within such datasets poses a number of statistical challenges. This course aims to provide students with a strong foundation in computing skills necessary to use R or Python to tackle some of these challenges. Possible topics to be covered may include exploratory data analysis and visualization, collecting data from a variety of sources (e.g. Excel, web-scraping, APIs and others), object-oriented programming concepts and scientific computation tools. Students will learn to create their own R packages or Python libraries.

STAT8020 Quantitative strategies and algorithmic trading
Quantitative trading is a systematic investment approach that consists of identification of trading opportunities via statistical data analysis and implementation via computer algorithms. This course introduces various methodologies that are commonly employed in quantitative trading. The first half of the course focuses on strategies and methodologies derived from the data snapshotted at daily or minute frequency. Some specific topics are: (1) techniques for trading trending and mean-reverting instruments, (2) statistical arbitrage and pairs trading, (3) detection of ‘time-series’ mean reversion or stationarity, (4) cross-sectional momentum and contrarian strategies, (5) back-testing methodologies and corresponding performance measures, and (6) Kelly formula, money and risk management. The second half of the course discusses statistical models of high frequency data and related trading strategies. Topics that planned to be covered are: (7) introduction of market microstructure, (8) stylized features and models of high frequency transaction prices, (9) limit order book models, (10) optimal execution and smart order routing algorithms, and (11) regulation and compliance issues in algorithmic trading.

STAT8021 Big data analytics
The recent explosion of social media and the computerization of every aspect of life resulted in the creation of volumes of mostly unstructured data (big data): web logs, e-mails, videos, speech recordings, photographs, tweets and others. This course aims to provide students with knowledge and skills of some advanced analytics and statistical modeling for solving big data problems. Topics include recommender system, deep learning: CNN, RNN, LSTM, GRU, natural language processing, sentiment analysis and topic modeling. Students are required to possess basic understanding of Python language.

COMP7308 Introduction to unmanned systems
To study the theory and algorithms in unmanned systems. Topics include vehicle modeling, vehicle control, state estimation, perception and mapping, motion planning, and deep learning related techniques.

COMP7309 Quantum computing and artificial intelligence
This course offers a theoretical overview of selected topics from the interdisciplinary fields of quantum computation and quantum AI. The scope of the lectures encompasses an accessible introduction to the fundamental concepts of quantum computation. Importantly, the introduction takes the angle of computer science and logic, such that no preliminary knowledge of quantum theory is required. Thereupon, detailed comparisons of computational principles and related phenomena in the classical and quantum domain outline the stark potential and challenges of quantum theory for fundamentally novel algorithms which are more powerful than possible with conventional computers. Thereupon, the theoretical capability of quantum computers is illustrated by analyzing a selection of milestone algorithms of quantum computation, and their potential applications to artificial intelligence.

COMP7409 Machine learning in trading and finance
The course introduces students to the field of Machine Learning and help them develop skills of applying Machine Learning, or more precisely, applying supervised learning, unsupervised learning and reinforcement learning to solve problems in Trading and Finance. This course will cover the following topics: (1) Overview of Machine Learning and Artificial Intelligence, (2) Supervised Learning, Unsupervised Learning and Reinforcement Learning, (3) Major algorithms for Supervised Learning and Unsupervised Learning with applications to Trading and Finance, (4) Basic algorithms for Reinforcement Learning with applications to optimal trading, asset management, and portfolio optimization, (5) Advanced methods of Reinforcement Learning with applications to high-frequency trading, cryptocurrency trading and peer-to-peer lending.

COMP7502 Image processing and computer vision
This course is to study the theory and algorithms in image processing and computer vision. Topics include image representation, image enhancement, image restoration, mathematical morphology, image compression, scene understanding and motion analysis.

ARIN7017 Legal issues in artificial intelligence and data science
Modern information systems have had unprecedented impact on privacy while building dependency on them. The immense social benefits of such systems as data mining and cloud computing must be weighed against potential dangers with consideration of methods of mitigation of risk. This course examines the growing legal, administrative, policy and technical issues associated with the use of artificial intelligence and information security and assurance. In particular, the relationship of data mining to information assurance and privacy are analyzed, and legislative responses studied.

Capstone Project
ARIN7800 Artificial intelligence project
Students will be required to attend an artificial intelligence ethics workshop and then carry out independent work on a major project under the supervision of staff members. A research report as well as an oral presentation on the research work and related ethics issues are required.

More course information at: https://www.scifac.hku.hk/prospective/tpg/ArtificialIntelligence
"Tapping into the AI expertise of our teaching team, we set out to nurture talents who will be geared up to meet the mounting demand for AI professionals both in Hong Kong and worldwide."

Programme Director and Head of Department of Mathematics
Professor Xiaoming YUAN
BSc, MPhil Nanjing U; PhD City U

Admissions

Requirements
- A Bachelor’s degree with honours, or equivalent qualification;
- Applicants should possess knowledge of linear algebra, calculus, probability theory, introductory statistics, and computer programming; and
- Fulfill the University Entrance Requirements.

How to apply

Application deadlines:
Main round: 12:00 noon (GMT +8), January 31, 2023
Clearing round: 12:00 noon (GMT +8), April 17, 2023

Online application:
admissions.hku.hk/tpg

Expected graduation time for normal course of studies
Summer (July 2025)

Further Information

Programme details
admissions.hku.hk/tpg

Support for students
www.cedars.hku.hk

Enquiries
Department of Mathematics
Tel: (852) 3917 2258  Email: mscai@maths.hku.hk

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Dr P LUO
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Dr J PAN
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PhD UC Berkeley

Professor Y Z YU