New Master of Science in ARTIFICIAL INTELLIGENCE

Nurturing talents in artificial intelligence

Apply now for entry in September 2022
### IS THE PROGRAMME FOR YOU

In this day and age, there is no doubt that artificial intelligence has become an indispensable part of our daily lives. Intelligence machines are everywhere, and enhanced efficiency and augmentation of human capabilities are among the upsides. One example of AI is machine learning, which means that machines can observe, analyze and make mistakes similar to human brains without being taught to do so. The prevalence of AI has powered its applications in different areas, such as scientific research, transportation and marketing. It is predicted that in future, AI will continue to be one of the most in-demand jobs.

The Master of Science in Artificial Intelligence [MSc(AI)] is an interdisciplinary taught postgraduate programme jointly offered by the Department of Mathematics (host), the Department of Statistics & Actuarial Science and the Department of Computer Science. Its academic focus is promoting the applications of mathematics, statistics and computer science to facilitate AI in decision-making and problem-solving for various organizations and enterprises within the private and public sectors.

### Programme Features

- **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

### World-class Rankings of HKU

- **Quacquarelli Symonds (QS)**
  - #22 World Rankings 2022
  - Asia Rankings 2021

- **Times Higher Education (THE)**
  - #30 World Rankings 2022
  - #4 Asia Rankings 2022

- **Clarivate Analytics’ Essential Science Indicators 2020**
  - 16.5% of our professoriate staff are the world’s Top 1% scholars

### 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 difference 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 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

### Programme Information

- **Tuition fees**
  - Composition fee: HK$350,000 (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.

*The fee shall generally be payable in 3 instalments over 1.5 years for full-time
Course Description

WHAT YOU WILL LEARN

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>ARIN7015</td>
<td>Statistics in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>COMP7002</td>
<td>Applied data mining and text analytics</td>
<td>6</td>
</tr>
<tr>
<td>COMP7004</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>
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</thead>
<tbody>
<tr>
<td>ARIN7011</td>
<td>Optimization in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>ARIN7015</td>
<td>Statistics in artificial intelligence</td>
<td>6</td>
</tr>
<tr>
<td>MATH7224</td>
<td>Topics in advanced probability theory</td>
<td>6</td>
</tr>
<tr>
<td>MATH8552</td>
<td>Topics in applied discrete mathematics</td>
<td>6</td>
</tr>
<tr>
<td>MATH8553</td>
<td>Topics in advanced optimization</td>
<td>6</td>
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</table>

List B:

<table>
<thead>
<tr>
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<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT6001</td>
<td>Computational statistics</td>
<td>6</td>
</tr>
<tr>
<td>STAT6008</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>STAT8021</td>
<td>Big data analytics</td>
<td>6</td>
</tr>
</tbody>
</table>

List C:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<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>COMP7500</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>
</tr>
</tbody>
</table>

Capstone project (12 credits)

ARIN7600 Artificial intelligence project (12 credits)

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, CG 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 major concepts underlying 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 pattern 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 is the science and engineering of making intelligent machines, especially intelligent computer programmes, while ML refers to 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**

**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.

**MATH8502 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.

**MATH8503 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**
This course aims to give students a background in modern computationally intensive methods in statistics. It emphasizes the role of computation as a fundamental tool of discovery in data analysis, of statistical inference, and for development of statistical theory and methods. Contents include: Bayesian statistics, Markov chain Monte Carlo methods including Gibbs sampler, the Metropolis-Hastings algorithm, and data augmentation; Generation of random variables including 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) algorithms; Integration including Laplace approximations, Gaussian quadrature, the importance sampling method, Numerical optimization and integration, EM algorithm and its variants, Simulation and Monte Carlo integration, Importance sampling and variance reduction techniques; and other topics such as Hidden Markov models, neural networks, and Bootstrap methods.
WHAT YOU WILL LEARN

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
This course is 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 an introduction to the interdisciplinary fields of quantum computation and quantum AI. The focus will lie on an accessible introduction to the elementary concepts of quantum mechanics, followed by a comparison between computer science and information science in the quantum domain. The theoretical capability of quantum computers will be illustrated by analyzing fundamental algorithms of quantum computation and their potential applications in AI.

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
ARIN7600 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
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PhD Tokyo

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Dr P LUO
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Dr K K Y WONG
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Admissions
Requirements

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

How to apply
Main Round Deadline: 12 noon, January 31, 2022 (GMT+8)
Clearing Round Deadline: 12 noon, March 31, 2022 (GMT+8)

Online application
admissions.hku.hk/tpg

Further Information
Programme details
Support for students

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

“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.”