MEMORANDUM

To: Senate Quality Assurance and Planning Committee (SQAPC) for A2s

From: Michel Barbeau, Director, School of Computer Science

CC: Charles Macdonald, Dean, Faculty of Science

Date: March 29, 2021

Subject: Major Modification to Bachelor of Computer Science Track A2

In the BCS Honours, every student follows a common core of content on programming languages, algorithms, operating systems, software engineering, databases, web applications and mathematical foundations. Through the common core, students learn to analyze problems, design efficient solutions, write programs to solve problems and conduct experiments to test properly. The focus is on software development and on algorithm design and analysis. The objective of the common core is to ensure a good balance of theoretical and applied content. Along with the core seven credits (14 courses) in computer science, two credits in Mathematics and Statistics are required. In addition, there is a common requirement for five credits (10 courses) not in computer science, Math/Stats or Engineering. Honours students are required to do a Honours project or thesis, in their fourth year. The most characteristic aspect of the BCS Honours program's structure is the ability of students to choose between the general option or from among the following streams: Algorithms, Computer and Internet Security, Computer Game Development, Management and Business, and Software Engineering. The different streams serve to reinforce the application of core computer science knowledge to disciplines that intersect with computer science. The individual streams are designed to meet the needs of the varying interests of the students. Students in the BCS Honours have also access to the Industrial Applications Internship Option.

This major modification is about adding the new stream entitled *Artificial Intelligence and Machine Learning* to program BCS Honours. The new stream includes a foundational course on artificial intelligence and two courses on advanced topics, namely, machine learning and neural networks.

Modification Description

A detailed description of the new stream in the CourseLeaf format follows. The three courses specific to the stream are: COMP 3106, COMP 4105 and COMP 4107. Their calendar entries follow.

COMP 3106 [0.5 credit]
Introduction to Artificial Intelligence
Principles and tools used in Artificial Intelligence. Fundamentals of Knowledge Representation. Methods for non-adversarial problem solving, including non-exhaustive and heuristic-based strategies for searching the state space. Methods for adversarial problem solving, modeled as two-person and multi-person games. Techniques applicable for inference and learning. Fundamentals of some AI paradigms such as Reinforcement Learning and Nature-Based computing.
Includes: Experiential Learning Activity

Precludes additional credit for COMP 4106 (no longer offered).
Prerequisite(s): COMP 2804, (COMP 2404 or SYSC 3010 or SYSC 3110) and (COMP 2402 or SYSC 2100).
Lectures three hours a week.

COMP 4105 [0.5 credit]
Machine Learning
A subset of topics in Artificial Intelligence that emphasize algorithms and statistical models that rely on patterns and inference. The topics include classification, regression, model evaluation, regularization, Decision trees, feature construction and reduction, Ensemble methods and Support Vector Machines. It also briefly surveys some clustering and unsupervised learning techniques. Finally, it will cover some of the fundamental aspects of Neural Networks and algorithmic fairness.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 3106 or COMP4106 (no longer offered)) and MATH 1104.
Lecture three hours a week.

COMP 4107 [0.5 credit]
Neural Networks
Theory and application of Neural Networks (NNs) to problems in machine learning. The topics include an explanation of the representation, transformation and compression of data, biological models, Hebbian learning and the Perceptron. The material examines numerous other NNs such as the feedforward and recurrent architectures and those that use advanced gradient descent techniques. It will also cover ensemble networks, the Self Organizing Map, and Convolutional NN algorithms. It finally provides a brief introduction to deep learning, and explains how all these phenomena can be applied to pattern recognition and sequence prediction.
Includes: Experiential Learning Activity
Prerequisite(s): (COMP 3106 or COMP4106 (no longer offered)) and (MATH 1104 or MATH 1107).
Lectures three hours a week.

Note that the three courses are remodeled optional courses that have been offered the to BCS students. COMP 3106, COMP 4105 and COMP 4107 respectively are revised versions of COMP 4106, COMP 4900A and COMP 4107 (old). The descriptions and prerequisites have been updated to ensure consistency of the courses specific to the new stream. Furthermore, data ethics modules will be added to COMP 3106 and COMP 4105. COMP 3106 will include a high level discussion on ethics and AI. COMP 4105 will go deeper and discuss techniques to help with AI fairness and trust in AI. We will add "data ethics" to the course descriptions of 3106 and 4105 next Fall on CourseLeaf.

Impact on Other Programs

There are no programs on campus offering a specialization in artificial intelligence and machine learning. We foresee no direct impact on other programs. We expect that when the stream will open, a few students from other computer science streams will apply for transfer in the Artificial Intelligence and Machine Learning stream, since the stream specific course start in the third year of the program.

Artificial intelligence and machine learning are currently very relevant topics in computer science. Fields such as transportation, finance, business, manufacturing, and agriculture are being transformed by artificial intelligence and machine learning. Machine learning is today's highest-profile research area in computer science. LinkedIn witnessed a 190% increase from 2015 to 2017 in terms of skills required for AI-based jobs[1]. An Analytics Insight report projects more than 20 million available jobs in artificial intelligence by 2023[2]. Moreover, several high technology positions require skills in machine learning[3].

During recruitment events, several candidates inquire about the availability of such a program at Carleton. The courses we presently offer on the topic are very popular. We expect the stream to attract of lot of good students.

Resources

We currently have three undergraduate courses specifically on the topics of artificial intelligence and machine learning (COMP 4106, COMP 4900A and COMP 4107). The stream will use updated versions of these three existing courses (COMP 3106, COMP 4105 and COMP 4107). Effectively, no new courses are required. In addition, the stream will use the core courses of the BCS programs.

Existing faculty will deliver the stream courses. They will also be able to support and superivise honours projects and theses in the area. We have faculty members specializing in artificial intelligence and machine Learning (El-Roby, Holden, Komeili, Oommen, Tsang, White) and a Canada Research Chair (Guo). We have also several other faculty members who have artificial intelligence and machine learning aspects in their research program. No new resources are required to support the stream.

CourseLeaf Description

Computer Science
Artificial Intelligence and Machine Learning Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.5 credits)

1. 6.5 credits in:	6.5
COMP 1405 [0.5] Introduction to Computer Science I	

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[1] Preetipadma, How will be the AI job market fare in coming years?, Analytics Insight, Nov. 24, 2020 [Online: https://www.analyticsinsight.net/how-will-be-the-ai-job-market-fare-in-coming-years/; Access: Feb. 15, 2021]
[2] Nathan Eddy, Artificial Intelligence (A.I.) Job Trends Important to Watch in 2021, Dice Nov. 16, 2020. [Online: https://insights.dice.com/2020/11/16/artificial-intelligence-a-i-job-trends-important-to-watch-in-2021/; Access: Feb. 15, 2021]
[3] Nick Kolakowski, As Companies Pour Millions into A.I., Job Opportunities Abound, Dice, July 16, 202 [Online: https://insights.dice.com/2020/07/16/companies-pour-millions-a-i-job-opportunities-abound/; Access: Feb. 15, 2021]

COMP 1406 [0.5]	Introduction to Computer Science II	
COMP 1805 [0.5]	Discrete Structures I	
COMP 2401 [0.5]	Introduction to Systems Programming	
COMP 2402 [0.5]	Abstract Data Types and Algorithms	
COMP 2404 [0.5]	Introduction to Software Engineering	
COMP 2406 [0.5]	Fundamentals of Web Applications	
COMP 2804 [0.5]	Discrete Structures II	
COMP 3000 [0.5]	Operating Systems	
COMP 3004 [0.5]	Object-Oriented Software Engineering	
COMP 3005 [0.5]	Database Management Systems	
COMP 3007 [0.5]	Programming Paradigms	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
2. 1.5 credits in:		**1.5**
COMP 3106 [0.0]	Introduction to Artificial Intelligence	
COMP 4105 [0.0]	Machine Learning	
COMP 4107 [0.5]	Neural Networks	
3. 1.5 credits from:		**1.5**
COMP 4905 and 1.0 credit in COMP at the 4000-level, or		
COMP 4906 and 0.5 credit in COMP at the 4000-level		
B. Credits Not Included in the Major CGPA (10.5 credits)		
4. 1.0 credit in:		**1.0**
MATH 1007 [0.5]	Elementary Calculus I	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
5. 0.5 credit from:		**0.5**
STAT 2605 [0.5]	Probability Models	
or 0.5 credit in MATH at the 2000-level or above		
6. 0.5 credit in:		**0.5**
STAT 2507 [0.5]	Introduction to Statistical Modeling I	
7. 5.0 credits in Breadth Electives		**5.0**
8. 3.5 credits in free electives		**3.5**
Total Credits		**20.0**

New Program Proposal

Date Submitted: 11/05/20 9:03 am

Viewing: **BCS-598 : Artificial Intelligence and Machine Learning Stream B.C.S. Honours**

Last edit: 03/30/21 10:33 am

Last modified by: robyngreen

Changes proposed by: edinastorfer

In Workflow

1. **COMP ChairDir UG**
2. **SCI Dean**
3. **COMP FCC**
4. **COMP FBoard**
5. **PRE SCCASP**
6. **SCCASP**
7. **SQAPC**
8. Senate
9. PRE CalEditor
10. CalEditor

Approval Path

1. 11/06/20 6:19 pm
   Michel Barbeau
   (michelbarbeau):
   Approved for COMP
   ChairDir UG
2. 11/11/20 1:57 pm
   Julia Wallace
   (juliawallace): Approved
   for SCI Dean
3. 11/11/20 2:09 pm
   Michel Barbeau
   (michelbarbeau):
   Approved for COMP FCC
4. 11/11/20 2:41 pm
   Michel Barbeau
   (michelbarbeau):
   Approved for COMP
   FBoard
5. 03/11/21 9:06 am
   Sarah Cleary
   (sarahcleary): Approved
   for PRE SCCASP
6. 03/17/21 9:07 am
   Erika Strathearn
   (erikastrathearn):
   Approved for SCCASP

Effective Date	2022-23
Workflow	majormod
Program Code	BCS-598
Level	Undergraduate

Faculty	Faculty of Science
Academic Unit	School of Computer Science
Degree	Bachelor of Computer Science
Title	Artificial Intelligence and Machine Learning Stream B.C.S. Honours

Program Requirements

Computer Science
Artificial Intelligence and Machine Learning Stream
B.C.S. Honours (20.0 credits)

A. Credits Included in the Major CGPA (9.5 credits)

1. 6.5 credits in: **6.5**

COMP 1405 [0.5]	Introduction to Computer Science I
COMP 1406 [0.5]	Introduction to Computer Science II
COMP 1805 [0.5]	Discrete Structures I
COMP 2401 [0.5]	Introduction to Systems Programming
COMP 2402 [0.5]	Abstract Data Types and Algorithms
COMP 2404 [0.5]	Introduction to Software Engineering
COMP 2406 [0.5]	Fundamentals of Web Applications
COMP 2804 [0.5]	Discrete Structures II
COMP 3000 [0.5]	Operating Systems
COMP 3004 [0.5]	Object-Oriented Software Engineering
COMP 3005 [0.5]	Database Management Systems
COMP 3007 [0.5]	Programming Paradigms
COMP 3804 [0.5]	Design and Analysis of Algorithms I

2. 1.5 credits in: **1.5**

COMP 3106 [0.0]	Introduction to Artificial Intelligence
COMP 4105 [0.0]	Machine Learning
COMP 4107 [0.5]	Neural Networks

3. 1.5 credits from: **1.5**

COMP 4905 and 1.0 credit in COMP at the 4000-level

or COMP 4906 and 0.5 credit in COMP at the 4000-level

B. Credits Not Included in the Major CGPA (10.5 credits)

4. 1.0 credit in: **1.0**

MATH 1007 [0.5]	Elementary Calculus I
MATH 1104 [0.5]	Linear Algebra for Engineering or Science

5. 0.5 credit from: **0.5**

STAT 2605 [0.5]	Probability Models

or 0.5 credit in MATH at the 2000-level or above

6. 0.5 credit in: **0.5**

STAT 2507 [0.5]	Introduction to Statistical Modeling I

7. 5.0 credits in Breadth Electives	**5.0**
8. 3.5 credits in free electives	**3.5**
Total Credits	20.0

New Resources	No New Resources
Summary	Adding of new stream Artificial Intelligence and Machine Learning.
Rationale	Artificial intelligence and machine learning are currently very relevant topics in computer science. There is growing demand for people with skills on these topics. While numerous students, potential and current, have been asking us to offer a specialization in the area. Data ethics modules will be added to COMP 3106 and COMP 4105. COMP 3106 will include a high level discussion on ethics and AI. COMP 4105 will go deeper and discuss techniques to help with AI fairness and trust in AI. We will add "data ethics" to the course descriptions of 3106 and 4105 next Fall in CourseLeaf.
Transition/Implementation	No impact.
Program reviewer comments	**sarahcleary (12/02/20 9:58 am):** Added program title to header. Minor formatting. **sarahcleary (01/12/21 8:55 am):** Minor formatting section 5. **sarahcleary (01/28/21 7:52 am):** Changed effective date to 2022-2023 as per OVPAVPA and moved to future cycle. **sarahcleary (02/25/21 9:59 am):** Minor edit to section 3. **elizabethbruce (03/09/21 3:23 pm):** Program code updated from TBD-2058 to BCS-598

Key: 2058