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SFU GRADUATE STUDIES

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MEMORANDUM

ATTENTION Senate

DATE October 8, 2024

FROM Mary O'Brien,
Chair of Senate Graduate Studies Committee (SGSC)

RE: New Courses

For information:
Acting under delegated authority at its meeting of September 10, 2024, SGSC approved the following new course(s), effective **Summer 2025**:

Faculty of Applied Science
School of Mechatronic Systems Engineering

1) New Course: MSE 713 Machine Learning in Mechatronics

Senators wishing to consult a more detailed report of curriculum revisions may do so on the Senate Docushare repository at https://docushare.sfu.ca/dsweb/View/Collection-12682

OFFICE OF THE DEAN
Faculty of Applied Sciences
Simon Fraser University

MEMORANDUM

Attention	Dr. Mary O'Brien Dean, Graduate Studies	July 2, 2024,
From	Dr. Parvaneh Saeedi, psaeedi@sfu.ca Faculty of Applied Science, Graduate Studies Committee	

Re: FAS - MSE ~~and SEE~~ New Graduate Courses

The Faculty of Applied Sciences Graduate Studies Committee would request creating the following a new courses:

1. **MSE 713 - Machine Learning in Mechatronics - effective Summer 2025**
   The justification for introducing this new course lies in the fact that the skills acquired through it are in high demand within both the industry and our research programs. Dr. Mohammad Narimani has successfully delivered this course twice as a special topic offering, receiving positive feedback from graduate students. Additionally, students pursuing the MSE Masters in Smart Manufacturing have expressed interest in this course. The course differs from graduate machine learning courses in computing science through its focus on applications of machine learning methods to problems in mechatronics.

2. ~~**SEE 795 - Industrial Internship - effective Summer 2025**~~
   ~~The introduction of the industrial internship course allows SEE graduate students to take full-time positions with industrial partners as interns for one term while remaining enrolled at SFU. Graduate students are seeking opportunities to participate in industrial internships while maintain their status as graduate students. SEE 795 will address this need.~~

3. ~~**SEE 830 - Energy Modelling for SDGs - effective Summer 2025**~~
   ~~We request to have the conversion of the special topic course, Energy Modelling for SDGs into a regular course, SEE 830. It has been successfully offered three times in the past.~~

4. ~~**SEE 870 - Sustainable Vehicle Propulsion Technologies - effective Fall 2025**~~
   ~~We request to have the conversion of the special topic course, Sustainable Vehicle Propulsion Technologies into a regular course, SEE 870. It has been successfully offered three times in the past.~~

Best Regards,

Parvaneh Saeedi,
Faculty of Applied Science, Graduate Studies Committee

SFU FACULTY OF APPLIED SCIENCES | SCHOOL OF MECHATRONIC SYSTEMS ENGINEERING

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MEMORANDUM

Date: October 18, 2023
To: Dr. Parvaneh Saeedi, FAS Associate Dean of Research
From: Dr. Carolyn Sparrey, Chair, Graduate Program Committee, Mechatronic Systems Engineering

Re: New Graduate Course – MSE 713 Machine Learning in Mechatronics

The School of Mechatronic Systems Engineering would like to propose a new graduate course MSE 713 – Machine Learning in Mechatronics. The rationale for this new course is the need for graduate courses in MSE. We have very few graduate level courses that are of broad interest to students across several research areas. This course has been offered twice by Dr. Mohammad Narimani as a special topics course and was well received by graduate students. This course is also of interest for students in the MSE Masters in Smart Manufacturing.

The course differs from graduate machine learning courses in computing science through its focus on applications of machine learning methods to problems in mechatronics.

Expanding our graduate course offerings to include more general topics like Machine Learning in Mechatronics, that are of interest to students across research foci will help MSE balance demand for graduate courses with teaching bandwidth and resources.

X_____

Carolyn Sparrey
Graduate Program Chair, School of Mechatronic Systems Engineering

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 713	Units (eg. 4) 3

Course title (max. 100 characters)

Machine Learning in Mechatronics

Short title (for enrollment/transcript - max. 30 characters **Machine Learning Mechatronics**

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description - max. 50 words)

The development and implementation of ML algorithms in mechatronic systems using ML packages in Python are discussed. Encompasses a wide range of well-established ML techniques, including supervised, unsupervised, and reinforcement learning algorithms. Emphasizing practical applications, students will acquire the skills to develop assessment techniques for comparing algorithm performance. Furthermore, they will gain hands-on experience in deploying ML algorithms in embedded systems, enabling them to effectively integrate machine learning into real-world mechatronic applications.

Rationale for introduction of this course

See page below

Term of initial offering (eg. Fall 2019) Summer2025	Course delivery (eg. 3 hrs/week for 13 weeks) 3 hrs/week for 13 weeks Lecture + 3 hrs/week for 13 weeks Lab
Frequency of offerings/year once a year	Estimated enrollment per offering 10 grad students

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

CMPT 726 and MSE413

Prerequisite and/or Corequisite

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☑ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☐ Yes ☑ No	Final exam required? ☐ Yes ☑ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☑ Yes ☐ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

Proposed in an extra page

* See important definitions on the curriculum website.

Rationale for introduction of this course

Today moat of the advanced mechatronic systems are highly complex and categorized into interdisciplinary studies. These stems are usually without a mathematical model to describe their dynamics behaviors. Additionally, in Industry 4.0 (smart manufacturing) machines needs to collaborate with each other and enhance interaction with environment to improve make decisions without human involvement. Analysis and development of these systems are difficult tasks. Machine learning (ML) algorithms can be used to mimic and predict the behavior and dynamics of complex system. These methods reliably produce and repeat results based on iterative leaning approach using acquired empirical data. With the promising advancements in computation technologies, ML techniques can be implemented in Micro-controller platforms and have drawn a great deal of attention among hi-tech companies and universities researchers.

On the other hand, interdisciplinary research fields and Smart Manufacturing are among active areas in the School of Mechatronic Systems Engineering (MSE). Undergraduate and graduate students who work on the development of these systems require learning ML techniques. Before offering this course, MSE students take the pertinent course (CMPT417/726: Machine Learning) from the School of Computing Science in the Burnaby campus. Although this course has held a solid and well-defined materials, it has been designed for Computing Science students, that is students need to spend majority of their time in the development of the core of ML techniques and algorithms, say developing cost function to make algorithms much faster and more effective. However, MSE students mostly need to learn how to choose and develop these algorithms in their projects with less emphasizes on algorithm development. Implementation of ML algorithms on embedded mechatronic systems is another area that this new course emphasizes on. Therefore, this new course aims to introduce to MSE students the application of machine learning techniques in mechatronic systems.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
Narimani
Additional faculty members, space, and/or specialized equipment required in order to offer this course
NA

CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
School of Mechatronic Systems Engineering	Dr Carolyn Sparrey	csparrey@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee Carolyn Sparrey	Signature	Date Oct 12, 2023
Department Chair John Zheng Shen	Signature	Date Oct 12, 2023

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? [x] YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee Parvaneh Saeedi	Signat	Date July 2, 2024

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee Mary O'Brien	Signature	Date October 11, 2024

ADMINISTRATIVE SECTION (for DGS office only)

Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Simon Fraser University
School of Mechatronic Systems Engineering
MSE 713 - Machine Learning in Mechatronics

Instructor:
Mohammad Narimani, *Ph.D., P.Eng*
Lecturer, School of Mechatronic Systems Engineering
Email: mnariman@sfu.ca
Office: SRYC 4148
Office hours: by appointment in-person or via Zoom

Communications:
All relevant material and announcements will be posted on Canvas

Lectures:
Tuesdays, 2:30 – 4:20 pm, SRYC3170
Fridays, 2:30 – 3:20 pm, SRYC3170

- ✓ Lecture times will be mostly used for catching up on lecture materials. Also, it will be used for the review of selected problems, guidance on course projects, general course material review, and assistance. To be discussed in the class.

Labs:
Wednesdays, 9:30 am– 12:20 pm, SRYE4024
Thursdays, 9:30 am– 12:20 pm, SRYE3024

- ✓ The structure of labs will be discussed later.

Prerequisites:
Undergrad students: minimum 80 credits, Digital Logic and Micro-controllers (MSE 352)

Course Description:

An introduction to machine learning (ML) packages in Python. An introduction to the development and implementation of ML algorithms in mechatronic systems (MS). It covers a wide variety of ML techniques including supervised, unsupervised and reinforcement learning algorithms. Students learn to develop and implement ML algorithms in embedded systems, also how to evaluate developed models. Students who have taken CMPT 419/726 may not take this course for further credit.

Course objectives:

This course is proposed to meet a growing business need of programming and software skills for the development and implementation of ML algorithms in mechatronic systems. The proposed course will combine theory and practice to enable the students to gain the necessary knowledge and skills to work on the analysis and design of complex monitoring, diagnostics, and control systems.

- Understand a wide variety of machine learning algorithms
- Understand how to evaluate models generated from data
- Implementation of the ML algorithms to real-world Diagnostics, Monitoring, and Control Systems problems

Textbooks:

1- Introduction to Machine Learning, forth Second Edition, Ethem Alpaydin, The MIT Press

2- Pattern Recognition and Machine Learning, Christopher M. Bishop, Springer (2006)

***Evaluation Scheme:**

4 Lab Assignments	40%, 10% each
Course Project	30%
Exam 1	15%
Exam 2	15%

Course Outline (timing to be adjusted as needed in the term)

Week 1 ***Introduction***

- Machine Learning and Self-Learning Algorithms
- Application of Machine Learning in Mechatronic Systems
- Supervised and unsupervised learning methods

Week 2-4 ***Useful Concepts in Machine Learning & An Introduction to Python***

- An Introduction to Python basics (1 week)
- An Introduction to Python for Data Science: NumPy, SciPy, Pandas, Scikit
- Regression and Gradient Descent (2 weeks)
- Overfitting and complexity; training set, validation set, test set

Week 5-11 ***Supervised Machine Learning Algorithms - Useful Concepts, Techniques and Algorithms***

- Classification and Logistic Regression (1.5 weeks)
- Support Vector Machines (1 week)
- k-Nearest Neighbors (KNN) (1 week)
- Decision Trees, Random Forests, and Naive Bayes (1.5 weeks)
- Neural Networks and Deep Learning (2 weeks)

Week 12-13 ***Unsupervised Machine Learning Algorithms***

- Hierarchical Clustering
- k-means Clustering

Exams:
Midterm1: March 1st
Midterm2: April 8th

Teaching Assistants:

Afagh Mohagheghi, Ph.D. Candidate email: amohaghe@sfu.ca

Samira Asadi Shekafti, Ph.D. student email: saa143@sfu.ca

Seyed Ashkan Tavassoli Kakhki, M.A.Sc. student email: sat15@sfu.ca

Project: Implementation of ML Algorithms for a Mechatronic System

- Development of ML algorithms for a set of real-life data
- Evaluation of the developed model
- Implementation of the ML algorithm in an MCU platform

Note: For grad students, the project is going to be a research project and the result should be publishable in a conference paper.

Additional Information:

- Teaching materials will be made available on Canvas
- Please check your Canvas and/or SFU email accounts regularly for course announcements, etc.
- It is important to familiarize yourself with the policies and guidelines about students at SFU, including but not limited to the following:
  Code of Academic Integrity and Good Conduct:
  http://www.sfu.ca/policies/gazette/student/s10-01.html
  Principles and Procedures for Student Discipline:
  http://www.sfu.ca/policies/gazette/student/s10-02.html

Grading Table:

Mark (%)	Grade	Performance
90-100	A+	
85-89	A	
80-84	A-	
76-79	B+	
73-75	B	
69-72	B-	Minimum to pass
65-68	C+	
60-64	C	
55-59	C-	
50-54	D	
< 50	F	

Key Differences between the Undergraduate and Graduate Components:

1- Assignments and Final Project:

In the undergraduate component of the course, students will engage in group projects for both assignments and the final project. In graduate component the focus will be on individual assignments and final project. This approach allows graduate students to delve deeper into their respective fields, promoting their expertise, and cultivating independent research and problem-solving capabilities.

2- Exam Level:

The examination component of the course will differentiate between undergraduate and graduate students by providing questions of varying complexity and depth. Graduate students will face more challenging questions, requiring them to demonstrate a deeper understanding of the subject matter, as well as an ability to apply advanced theoretical concepts.

3- Final Project Expectations:

The final project for graduate students will have additional expectations beyond those of the undergraduate students. To ensure the project's scholarly significance, graduate students' final projects should incorporate a minimum level of novelty and potential for publication in conference papers. This requirement encourages originality, critical thinking, and the development of research skills necessary for the pursuit of advanced degrees.