Magna University

Artificial Intelligence in Automotive and Manufacturing Applications 1.

12 half-day course modules delivered online via MS Teams

Twelve consecutive Tuesdays: Apr 4, 11, 18, 25; May 2, 9, 16, 23, 30; Jun 6, 13, 20, 2023
8:00 am – 12:00 pm (EST); 1:00 pm – 5:00 pm (GMT); 2:00 pm – 6:00 pm (CET)

This course is part of the Magna University course offerings and is free of charge to all Magna employees and at no cost to their divisions.

This course is open to every Magna employee; however, those who are officially enrolled in the Magna M.Eng. or Certificate program offered by the University of Toronto will be given priority if spots are limited. Upon successfully completing this course, employees are eligible for one academic credit towards an M.Eng. degree or Certificate from the University of Toronto. Enrollment in this course is on a first-come, first-serve basis.

The Magna University program is designed by Magna, managed by the University of Toronto, and delivered on-site at Magna or online for Magna by the University of Toronto and 14 other universities using academics and leading industry experts. The program offers a variety of courses that combine both theoretical and hands-on practical aspects to meet the needs of Magna employees who need to apply the newly gained skills to their daily work. Input for the curriculum, course content, and practical exercises, as well as an indication of the need for additional specific courses, are provided by Magna divisions. Lecturers are handpicked from several universities, leading technology companies, and industry experts based on their automotive-related practical experience.

For registration for this course, please contact the Magna University program office at scfi@magna.com with "Artificial Intelligence 1. course" in your email's subject line.

For further information on this course or the Magna University program, please contact:

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Artificial Intelligence in Automotive and Manufacturing Applications 1.

course outline

This course introduces participants to data science and artificial intelligence through automotive and manufacturing applications. To ensure that this course is best tailored to the needs of Magna, all concepts will be introduced and demonstrated using real-life data from Magna manufacturing lines representing various Magna groups.

Collecting, structuring, visualizing, and analyzing manufacturing data using Python with common scientific packages will be at the core of the course. Interspersed with real-world manufacturing problems will be theoretical foundations of supervised and unsupervised learning algorithms, probability and statistics, matrices and linear algebra, and continuous optimization. Basic working knowledge of Python and common scientific packages is required; therefore, completing the Magna University course "Python: Introduction to Coding for Artificial Intelligence and Mechatronics" is a prerequisite.

Participants will learn to:

- Improve and optimize automotive and similar manufacturing processes (e.g., metal forming, polymer/composite injection moulding, welding & joining, painting, electronics manufacturing, assembly, logistics and warehousing, and quality inspection) by identifying opportunities and deploying AI techniques.
- Collect, clean, structure, and visualize real-life unstructured and structured data from manufacturing processes using Python scientific packages.
- Understand the mathematical foundations (e.g., linear algebra, analytic geometry, probability and statistics, vector calculus, and optimization) required for data science and AI.
- Describe and apply dimensionality reduction methods (e.g., PCA and SVD) for the interpretation and selection of features.
- Apply data science and AI techniques to identify patterns/trends and guide decisions based on automotive and manufacturing data.
- Describe and implement several learning algorithms/models (e.g., KNN, decision trees, K-means, linear/logistic regression, neural networks, and deep learning) to industrial processes.
- Train and evaluate the effectiveness of learning algorithms/models (e.g., precision vs. recall, confusion matrix, and receiver operating characteristic).
- Determine which data science and AI techniques are best suited to a given manufacturing application.

Prerequisites:

Magna University course "Python: Introduction to Coding for Artificial Intelligence and Mechatronics", which also covers the Scientific Stack (Numpy, Scipy, Matplotlib) and Scikit-Learn. Python skills alone are not enough to take AI. Proof of completion of similar courses elsewhere should be submitted to SCFI for review as equivalence.

Other AI courses:

The "AI 2" course – to which this "AI 1" is a pre-requisite - is dedicated to deep learning using neural networks. Key applications include image processing and autonomous vehicles.

MIE 1769H Artificial Intelligence in Automotive and Manufacturing Applications 1.

Structure of the 12 half-day course modules
delivered live via MS Teams globally in a one module per week format

Exploratory Data Analysis	Measuring Uncertainty	Probability Theory	Linear Algebra	Linear Regression	Logistic Regression
Module 1	**Module 3**	**Module 5**	**Module 7**	**Module 9**	**Module 11**
course overview **end-to-end workflow** of applied data science	motivation/recap **welding** for evaluating performance	motivation/recap **powertrain good/bad** imbalanced dataset	motivation/recap **vehicle classification** for data augmentation	motivation/recap **powertrain (or airplane)** for linear regression	motivation/recap **vehicle classification** dataset for deep learning
lecture/examples	lecture/examples	lecture/examples	lecture/examples	lecture/examples	lecture/examples
topics: regex, distribution of data, trend/change detection, summary statistics (histograms, scatterplots, mean, variance, correlations, outliers/anomalies, etc.)	**topics:** generalization, precisions, recall, receiver operating characteristics (ROC) curves, nested cross-validation, confusion matrix, random forest bagging, boosting (regression vs classification)	**topics:** probability theory, combinatorics, distributions and Gaussians, correlation matrix	**topics:** linear algebra, eigendecomposition, analytic geometry, solving linear equations	**topics:** model-based learning, linear regression, direct solution and gradient descent, vector calculus	**topics:** classification, logistic regression, neural networks, and introduction to support vector machines (SVMs), and Deep Learning (CNNs), one-class problems
examples: - survey/article search - Titanic-like dataset - wine data	**examples:** - fraud detection - iris and mnist dataset	**examples:** - naïve Bayes spam/ham - fraud detection	**examples:** - rotation of vehicle images	**examples:** - airplane controller (or as assignment)	**examples:** - MNIST - car vs truck
activity (paired)	activity (paired)	activity (paired)	activity (paired)	activity (paired)	activity (paired)
application: welding machine data for change detection **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** powertrain for evaluating performance **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** powertrain anomaly dataset (pass/fail) **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** vehicle classification for data augmentation **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** powertrain application for linear regression **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** vehicle classification dataset for deep learning **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions

Supervised Learning	Unsupervised Learning	Anomaly Detection	Dimensionality Reduction	Nonlinear Regression	Deep Learning
Module 2	**Module 4**	**Module 6**	**Module 8**	**Module 10**	**Module 12**
motivation/recap **welding** for regression and classification problems	motivation/recap **injection molding** application for clustering	motivation/recap **powertrain good/bad** for anomaly detection	motivation/recap **injection molding** for feature interpretation	motivation/recap **powertrain** for nonlinear regression	motivation/recap **soldering dataset** for transfer learning
lecture/examples	lecture/examples	lecture/examples	lecture/examples	lecture/examples	lecture/examples
topics: instance-based learning, regression, classification, supervised, unsupervised, k-nearest neighbours (kNN), decisions trees.	**topics:** clustering, k-means, hierarchical and density based	**topics**: Monte Carlo sampling methods, confidence intervals, hypothesis testing Gaussian mixture models for anomaly detection	**topics:** dimensionality reduction and interpretations, principal component analysis (PCA) and singular value decomposition (SVD), feature selection	**topics:** polynomial regression and other feature mappings, regularization (lasso, ridge, etc.) Neural networks for nonlinear regression, lead into deep learning	**topics:** course summary and deep learning case study, (optional) introduce cloud computing platforms for deployment
examples: - classification toy data (something like Titanic)	**examples:** - blobs example (toy data) - image compression	**examples:** - fraud detection anomaly	**examples:** **-** eigenfaces - vehicles latent space	**examples:** **-** injection molding spline - airplane controller	**examples:** - quality inspection
activity (paired)	activity (paired)	activity (paired)	activity (paired)	activity (paired)	activity (paired)
application: welding application for regression and classification **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** injection molding dataset **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** injection molding (or) for anomaly detection **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** injection molding for feature interpretation/selection **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application:** powertrain application for nonlinear regression **-** introduce application and homework assignment - apply techniques from lectures to this dataset - complete some of the assignment questions	**application**: vision inspection for classification and localization of solder defects on electrical boards using deep neural networks - applied data science and deployment of models - complete some of the assignment questions

Assignment 1:	**Assignment 2:**	**Assignment 3:**	**Assignment 4:**	**Assignment 5:**	**Assignment 6:**
continuation from module 1 and 2 activities (due by next lecture)	continuation from module 3 and 4 activities (due by next lecture)	continuation from module 5 and 6 activities (due by next lecture)	continuation from module 7 and 8 activities (due by next lecture)	continuation from module 9 and 10 activities (due by next lecture)	continuation from module 11 and 12 activities (due in two weeks)