MSDS 458 DSP Section 61

Artificial Intelligence and Deep Learning
Course Syllabus

Course Lead Faculty Contact Information

Instructor: Edward Arroyo, PhD

Email: edward.arroyo@northwestern.edu

Office Hours: By appointment

Response Time: Response to emails within 24-48 hours

Optional Synchronous Meetings: TBD

Biography

I was born and raised in NYC but am currently living in South Carolina. After obtaining my Ph.D. in Mathematics from the Graduate School and University Center of CUNY, I spent many years teaching for various mathematics and computer science departments in universities in NY, Georgia and South Carolina. I then decided to see what life outside of academia was like and spent a few years working in the software industry in Princeton, NJ. I enjoyed my work and living in Princeton, NJ but I missed teaching and my family and I decided to give online teaching a try. It has been a lot of fun for me so far. I hope you will enjoy this class as much as I will enjoy teaching.

DSP Instructor Contact Information

DSP Instructor: Dr. Narayana Darapaneni

Pronouns: He/Him
Email: narayana.darapaneni@northwestern.edu

Links: https://www.linkedin.com/in/darapaneni/

Google Scholar: https://scholar.google.com/citations?authuser=4&user=b7RXqoYAAAAJ

Office Hours: TBA

Optional Synchronous Meetings: TBD

Biography

Dr. Narayana holds a PhD in Mathematics from Pierre and Marie Curie University, Paris, France. After completing his PhD, he worked as quantitative researcher, algorithmic trader, trader researcher and portfolio manager. He joined Great Learning in 2017 as Professor & Program Director, Big Data and Machine Learning. Now he is Professor & Academic Director, Artificial Intelligence and Machine Learning. He also takes care of Artificial Intelligence and Machine Learning research at Great Learning. His research interests include health analytics, computer vision applications, Psephology, security analytics, legal analytics etc. He has published over 60 research articles in international journals and conferences.

Teaching Assistant

TA: Mr. Aniket Chhadra

Pronouns:

Email: aniket.chhabra@northwestern.edu

Links:

Office Hours: TBA

Optional Synchronous Meetings: TBD

Biography

Mr. Aniket is an experienced AIML Expert with over 12 years of expertise. He has a strong background in developing and implementing Data Science solutions and has successfully led the Product in fintech domain. Aniket's areas of expertise include machine learning, deep learning, natural language processing, and data mining. He has actively participated in various AI projects and has a proficient knowledge of programming languages such as Python and SQL. Aniket is known for his excellent communication skills, effective collaboration with cross-functional teams, and his commitment to achieving excellence. He is passionate about leveraging his skills to drive innovation and make a significant impact.

Syllabus over Canvas Course Site

This syllabus in its Adobe Acrobat Portable Document Format (pdf) form is the defining document for this section of MSDS 458. This syllabus defines course objectives, requirements, due dates, and grading standards. If there is ever a discrepancy between this syllabus and the Canvas course site, rely on this syllabus as the final word.

Course Description

An introduction to the field of artificial intelligence, this course illustrates probability-rule-based generative models as well as discriminative models that learn from training data. The course reviews applications of artificial intelligence and deep learning in vision and language processing. Students learn best practices for building supervised learning models and, in particular, deep neural networks for classification and regression. Students also learn about feature engineering, autoencoders, and strategies of unsupervised and semi-supervised learning, as well as reinforcement learning. This is a project-based course with extensive programming assignments.

Course Learning Objectives

By the end of this course, you should be able to:

- Identify key phases in the history of artificial intelligence (AI), including deep learning.
- Distinguish among supervised, unsupervised, and reinforcement learning.
- Describe the structure and operation of neural networks, including deep learning networks.
- Employ neural networks and deep learning to address classification and regression problems (supervised learning with backpropagation).
- Employ probability-rule-based, generative models for deep learning.
- Describe the relevance of AI and deep learning methods to a wide range of applications, including vision and natural language processing.

Prerequisites

MSDS 420-DL Database Systems and Data Preparation or CIS 417 Database Systems Design and Implementation and (2) MSDS 422-DL Practical Machine Learning or CIS 435 Practical Data Science Using Machine Learning.

Required and Optional Readings and Resources

Required Textbooks

The following required book are available for free from **Safari Books online** through Northwestern Library: https://www.library.northwestern.edu/. Use your netid and email handle to access these book and chapters.

- Chollet, F. 2022. *Deep Learning with Python 2nd Edition*. Shelter Island, N.Y.: Manning. [ISBN-13: 978-1617296864]
    - https://learning.oreilly.com/library/view/deep-learning-with/9781617296864/
    - Source code available at: https://github.com/fchollet/deep-learning-with-python-notebooks.git

Reference Textbooks (Available Online)

- Glassner, Andrew 2021. *Deep Learning: A Visual Approach*. San Francisco, CA No Starch Press [ISBN-13: 978-1-7185-0072-3 (print), ISBN-13: 978-1-7185-0072-0 (ebook)] https://learning.oreilly.com/library/view/deep-learning/9781098129019/
- Goodfellow, I. Bengio, Y. and Courville, A. 2016. *Deep Learning.* Cambridge Mass.: MIT Press. [ISBN-13: 978-0262035613] This is a highly regarded textbook. It is also very mathematical and abstract. Other texts may be more suitable as introductions. Available online at: https://www.deeplearningbook.org
- Nilsson, N. J. 2010. *The Quest for Artificial Intelligence: A History of Ideas and Achievements.* New York: Cambridge University Press. [ISBN-13: 978-0-521-12293-1] Available online at: http://ai.stanford.edu/~nilsson/QAI/qai.pdf

Course Reserves

Selected readings are available through the Course Reserves. For assistance with Course Reserves, use electronic mail: e-reserve@northwestern.edu. To ask a librarian for assistance, visit Northwestern's Ask A Librarian page.

Optional Readings and Resources

- Géron,, A. 2019. Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems (second ed.), Sebastopol, Calif.: O'Reilly. [ISBN-13: 78-1492032649] Used as one of the required textbooks in MSDS 422, a prerequisite for this course. Source code available at https://github.com/ageron/handson-ml2
- Maren, A. J., Pap, R. M., and Harston, C. T., 1990. *Handbook of Neural Computing Applications.* New York: Academic Press. Accessible via Google Books. ***Note:*** These chapters are being supplanted by new chapter drafts in Maren's *Statistical Mechanics, Neural Networks, and Artificial Intelligence* book.
- Russell, S. J. and Norvig, P. 2015. *Artificial Intelligence: A Modern Approach* (third ed.). Upper Saddle River, N.J.: Pearson. Encyclopedic reference on the field.
- https://github.com/songrotek/Deep-Learning-Papers-Reading-Roadmap - a very good place to start, begins with the text that we'll be using; this is a curated list.
- Deng, L. and Yu, D., *Deep Learning: Methods and Applications*: (a 197-page monograph): http://research.microsoft.com/pubs/209355/DeepLearning-NowPublishingVol7-SIG-039.pdf
- Reading list for the Carnegie Mellon University course on Deep Learning, taught by Bhiksha Raj: http://deeplearning.cs.cmu.edu/ (Includes a number of classic neural network papers.)
- Because AI and deep learning are fast-moving fields, new readings (required and optional) may be introduced throughout the term.

Assignments and Grading Scale

Grading: Grading and feedback turnaround will be one week from the due date. You will be notified if turnaround will be longer than one week. The discussion forums and written assignments will be graded based on specific grading guidelines.
Language(s): The course employs Python with TensorFlow and Keras.
Assignments: There are no quizzes or exams. Rubrics are provided for assignments.

Class Participation	Graded discussion threads (10 points per week)	100 Points
Assignment 1	First Research/Programming Assignment (Week 2)	100 Points
Assignment 2	Second Research/Programming Assignment (Week 4)	100 Points
Assignment Proposal	Proposal for Fourth Research /Programming Assignment (Week 5)	0 Points
Assignment 3	Third Research/Programming Assignment (Week 6)	100 Points
Assignment 4	Fourth Research/Programming Assignment: Deep Learning (Complete one of many options) (Week 10)	100 Points
	Total	500 Points

Grade	Percentage	Total Points (out of 500)
A	93%–100%	465– 500 points
A-	90%–92%	450 – 464 points
B+	87%–89%	435 – 449 points
B	83%–86%	415 – 434 points
B-	80%–82%	400 – 414 points
C+	77%–79%	385 – 399 points
C	73%–76%	365 – 384 points
C-	70%–72%	350 – 364 points
F	0%–69%	0 – 349 points

Course Procedures

Assignment Due Dates

Each Monday introduces a new week, and its corresponding weekly Module. All discussions and assignments are due Sunday evening at 11:55 p.m. Central time.

Participation and Attendance

This course follows the asynchronous distance learning approach of Northwestern University School of Profession Studies. The course does not meet at a particular time each week. Learning objectives and assessments are supported through classroom elements that can be accessed at any time. To measure class participation (or attendance), your participation in threaded discussion boards is required, graded, and paramount to your success in this course.

Real-time, synchronous meetings (Sync Sessions) are scheduled for Thursday evenings on selected weeks. Sync Sessions are conducted with WebEx. While your attendance is highly encouraged, it is not required. You will not be graded on your attendance or participation. All Sync Sessions are recorded.

Refer to the weekly schedule at the end of this syllabus for details about weekly learning objectives, required and optional readings, assignments, and Sync Sessions.

Late Assignment Turn-Ins

Students should provide written notification of late assignment work 24 hours prior to the deadline. A grace day is allowed for those who provide late work notification. Late papers may be subject to point reductions.

Discussion Forums

The purpose of the discussion boards is to allow students to freely exchange ideas. It is imperative to remain respectful of all viewpoints and positions and, when necessary, agree to respectfully disagree. While active and frequent participation is encouraged, cluttering a discussion board with inappropriate, irrelevant, or insignificant material will not earn additional points and may result in receiving less than full credit. Frequency matters, but contributing content that adds value is paramount. Please remember to cite all sources—when relevant—in order to avoid plagiarism. Please post your viewpoints first and then discuss others' viewpoints.

The quality of your posts and how others view and respond to them are the most valued. A single statement mostly implying "I agree" or "I do not agree" is not counted as a post. Explain, clarify, politely ask for details, provide details, persuade, and enrich communications for a great discussion experience. Please note, there is a requirement to respond to at least two fellow class members posts. Also, remember to cite all sources—when relevant—in order to avoid

plagiarism. The initial response to the prompt is due by Thursday and all follow-up posts by Sunday night.

Online Communication Etiquette

Beyond interacting with your instructor and peers in discussions, you will be expected to communicate by Canvas message, email, and sync session. Your instructor may also make themselves available by phone or text. In all contexts, keep your communication professional and respect the instructor's posted availability. To learn more about professional communication, please review the Communicating Effectively with Faculty guide.

Just as you expect a response when you send a message to your instructor, please respond promptly when your instructor contacts you. Your instructor will expect a response within two business days. This will require that you log into the course site regularly and set up your notifications to inform you when the instructor posts an announcement, provides feedback on work, or sends you a Canvas message. For guidance on setting your notifications, please review How do I set my Canvas notification settings as a student? It is also recommended that you check your u.northwestern e-mail account regularly, or forward your u.northwestern e-mail to an account you check frequently.

In this class, in all interactions, it is important that we each remain respectful of the viewpoints and positions of others. When necessary (as some conversations may become spirited), we may have to "agree to disagree."
Discussion board posting should be used exclusively for topic-related postings; posting inappropriate, irrelevant, or insignificant material will actually earn you a negative score.

Frequency is not unimportant, but content of the message is paramount. A rubric for evaluating discussion posts will be provided within the first week of class. When you use material from an external source, please follow full professional (academic) citation styles, so that you (and others) can reference this material later. (Keep in mind that citing sources is a means of avoiding plagiarism.) For more information, read the 10 Rules of Netiquette.

Student Support Services

AccessibleNU

This course is designed to be welcoming to, accessible to, and usable by everyone, including students who are English-language learners, have a variety of learning styles, have disabilities, or are new to online learning. Be sure to let me know immediately if you encounter a required element or resource in the course that is not accessible to you. Also, let me know of changes I can make to the course so that it is more welcoming to, accessible to, or usable by students who take this course in the future.

Northwestern University and AccessibleNU are committed to providing a supportive and challenging environment for all undergraduate, graduate, professional school, and professional studies students with disabilities who attend the University. Additionally, the University and AccessibleNU work to provide students with disabilities and other conditions requiring accommodation a learning and community environment that affords them full participation, equal access, and reasonable accommodation. The majority of accommodations, services, and auxiliary aids provided to eligible students are coordinated by AccessibleNU, which is part of the Dean of Students Office.

SPS Student Services

The Department of Student Services supports the academic and professional growth of SPS students. The Student Services team guides students through academic planning, policies, and administrative procedures, and promotes a supportive environment to foster student success. Students are encouraged to actively make use of the resources and staff available to assist them: Academic and Career Advisers, Counseling and Health Services, Student Affairs, Legal Services, Financial Aid and Student Accounts, among other services.

For a comprehensive overview of course and program processes and policies and helpful student resources, please refer to your SPS Student Handbook.

Academic Support Services

Northwestern University Library

As one of the leading private research libraries in the United States, Northwestern University Library serves the educational and information needs of its students and faculty as well as scholars around the world. Visit the Library About page for more information or contact Distance Learning Librarian Tracy Coyne at 312-503-6617 or tracy-coyne@northwestern.edu.

Program-Specific Library Guides

- Information Systems
- Data Science

Additional Library Resources

- Connectivity: Campus Wireless and Off-Campus Access to Electronic Resources
- Reserve a Library Study Room
- Sign up for an in-person or online Research Consultation Appointment
- Getting Available Items: Delivery to Long-Distance Patrons
- Social Science Data Resources
- Resources for Data Analysis

Recommendations about Writing

The Writing Place is Northwestern's center for peer writing consultations. Consultations are free and available to anyone in the Northwestern community: undergraduates, graduate students, faculty, or staff. To book an appointment, go to The Writing Place website.

In his essay "Politics and the English Language," George Orwell (1946) provided six rules of clear writing:

- Never use a metaphor, simile, or other figure of speech which you are used to seeing in print.
- Never use a long word where a short one will do.
- If it is possible to cut a word out, always cut it out.
- Never use the passive where you can use the active.
- Never use a foreign phrase, a scientific word, or a jargon word if you can think of an everyday English equivalent.
- Break any of these rules sooner than say anything outright barbarous.

Zinzer (2012) provides additional writing advice.

References on Writing

Merriam-Webster's Collegiate Dictionary (eleventh ed.), 2008. Springfield, Mass.: Merriam-Webster.

Orwell, G., 1946, April. Politics and the English Language. *Horizon*. Available online at http://www.orwell.ru/library/essays/politics/english/e_polit

Publication Manual of the American Psychological Association (sixth ed.), 2009. Washington D.C.: American Psychological Association.

Rodale, J. I, L. Urdang, and N. LaRoche, 1978. *The Synonym Finder*. Emmaus, Pa.: Rodale Press.

The Chicago Manual of Style (sixteenth ed.), 2010. Chicago: University of Chicago Press. Online information available at http://www.chicagomanualofstyle.org/home.html

Zinsser, W., 2012. *On Writing Well: An Informal Guide to Writing Nonfiction* (Thirtieth Anniversary Edition). New York: Harper Perennial.

The Math Place

The Math Place is a free tutorial service provided to students currently enrolled in Northwestern University's School of Professional Studies courses or in other Northwestern University courses. Students of all levels can benefit from the individual tutoring provided from this service, whether they are taking undergraduate or graduate level courses. To book an appointment, go to The Math Place website.

Academic Integrity at Northwestern

Students are required to comply with University regulations regarding academic integrity. If you are in doubt about what constitutes academic dishonesty, speak with your instructor or graduate coordinator before the assignment is due and/or examine the University Web site. Academic dishonesty includes, but is not limited to, cheating on an exam, obtaining an unfair advantage, and plagiarism (e.g., using material from readings without citing or copying another student's paper). Failure to maintain academic integrity will result in a grade sanction, possibly as severe as failing and being required to retake the course, and could lead to a suspension or expulsion from the program. Further penalties may apply. For more information, visit The Office of the Provost's Academic Integrity page.

Some assignments in SPS courses may be required to be submitted through Turnitin, a plagiarism detection and education tool. You can find an explanation of the tool here.

Course Technology

This course will involve a number of different types of interactions. These interactions will take place primarily through the Canvas system. Please take the time to navigate through the course and become familiar with the course syllabus, structure, and content and review the list of resources below.

Canvas

The Canvas Student Center includes information on communicating in Canvas, navigating a Canvas course, grades, additional help, and more. The Canvas at Northwestern website provides information of getting to know Canvas at Northwestern and getting Canvas support. The Canvas Student Guide provides tutorials on all the features of Canvas. For additional Canvas help and support, you can always click the Help icon in the lower left corner to begin a live chat with Canvas support or contact the Canvas Support Hotline.

The Canvas Accessibility Statement and Canvas Privacy Policy are also available.

Python, TensorFlow, and Keras

This course will use the programming language Python and the TensorFlow and Keras packages. Python can be downloaded at Anaconda. Download and install the Python 3.6 version of Anaconda. Additional documentation on downloading and installing Anaconda can be found at Anaconda Documentation. After installation, you should be able to access the Anaconda Navigator. To work with a Python-aware editor and an iPython shell, Spyder is recommended. This graphical user interface can be launched via the Anaconda Navigator. This course will also be using Jupyter notebooks to build and store Python files for various assignments. Jupyter can also be launched via the Anaconda Navigator.

Zoom

We will use Zoom for optional synchronous meetings. You can review the Privacy Policy here and the Accessibility statement here.

Please note that any scheduled synchronous meetings are optional. While your attendance is highly encouraged, it is not required and you will not be graded on your attendance or participation. These synchronous sessions will be recorded, so you will be able to review the session afterwards.

Zoom video conferencing is available for student use in optional study teams.

Panopto

Videos in this course may be hosted in Panopto. If you have not used Panopto in the past, you may be prompted to login to Panopto for the first time and authorize Panopto to access your Canvas account. You can learn more about using Panopto and login to Panopto directly by visiting the Panopto guide on the Northwestern IT Resource Hub. Depending on the assignment requirements of this course, you may be asked to create videos using Panopto in addition to viewing content that your instructor has provided through Panopto.

The Panopto Privacy Policy and the Accessibility Features on Panopto are also available.

Minimum Required Technical Skills

Students in an online program should be able to do the following:

- Communicate via email and Canvas discussion forums.
- Use web browsers and navigate the World Wide Web.
- Use the learning management system Canvas.
- Use integrated Canvas tools (e.g., WebEx, Zoom, Panopto, Course Reserves).
- Use applications to create documents and presentations (e.g., Microsoft Word, PowerPoint).
- Use applications to share files (e.g., Box, Google Drive).
- Use software for predictive analytics (e.g., Python, TensorFlow, Keras).

Technical Help and Support

The SPS Help Desk is available for Faculty, Students and Staff to support their daily IT needs. For additional technical support, contact the Northwestern IT Support Center.

Course Calendar

1) The pages that follow show the plan for topics and assignments week-by-week.
2) In the syllabus and Canvas course site, “week,” “session,” and “module” are synonymous.
3) Changes to the syllabus will be posted to the Canvas course site with an Announcement.

Weekly Calendar with Assignments

- Week 1. Computational Frameworks and How Neural Networks Came Into Being
- Week 2. Simple Neural Networks: Architectures and Design Principles
  First Research/Programming Assignment
- Week 3. Deep Neural Networks: Architectures and Design Principles
- Week 4. Spatial (Image) Data Processing—Convolutional Neural Networks,
  Second Research/Programming Assignment
- Week 5. Temporal Data Processing—Recurrent Neural Networks (RNNs),
  Proposal for Fourth Research/Programming Assignment
- Week 6. Natural Language Processing with RNNs, LSTMs and 1D CNNs
  Third Research/Programming Assignment
- Week 7. Deep Generative Learning: Autoencoders and GANs
- Week 8. Reinforcement Learning
- Week 9. Interpretability, Bias, and Ethical AI Including US Bill of Rights
- Week 10. Final Project Presentations
  Fourth Research/Programming Assignment

Week 1

The Multilayer Perceptron (MLP) in Action

Learning Objectives

After completing Module 1, the student should be able to:

- ***Define and give examples*** for ***Week 1 key terms and concepts***,
- ***Describe*** *structure and operation of a MultiLayer Perceptron (MLP)*, at both:
  - The microstructure level - the internal structure of a neural "node" or computational unit, and
  - The mesostructure level - the actual architecture and configuration of the network,
- ***Write and describe*** functionality for the different kinds of transfer functions equations, characterizing different microstructure (node-level) functional options, obtain the derivative of each, and identify which transfer function(s) you would choose to use for different network layers, and why you would make these choices:
  - Sigmoid transfer function,
  - Logistic transfer function, and
  - ReLU and approximate ReLU transfer function,
- ***Understand the learning equations for a MLP trained with back-propagation***, for both:
  - Output-to-hidden layer weight connections and their learning rule updates, and
  - Hidden-to-input layer weight connections and their learning rule updates.

- ***Explore*** *neural nets/seeing how they work on a very simple problem,*
- ***Examine*** *alternative neural net structures with a simple, single-hidden layer network, and*
- ***Learn*** *how to fit a neural network directly in Python (or Scikit Learn, TensorFlow, or Keras).*
- ***Describe the nature and particular significance*** **of the X-OR problem**, as a challenge that a trained neural network can solve, and
- ***Assess and evaluate the influence of different parameters in the neural network code on training and performance***:
  - "Eta" - the learning rate,
  - "Alpha" - the steepness of the transfer function, and
  - "Epsilon" - the criteria for accepting that the network has been sufficiently trained.
- ***Describe the connection weight values as an overall "pattern" (positive or negative values, large or small), and also how the hidden node activations respond to the input patterns once the network is trained.***

Required Readings:

- See Canvas.

Sync Session

Python code walkthrough– on the assigned day of the week.
Sync Session attendance is optional. Each Sync Session is recorded.

Week 2

Simple Neural Networks: Architectures and Design Principles

Learning Objectives

After completing Module 2, the student should be able to:

- ***Define and give examples*** for ***Week 2 key terms and concepts***,
- ***Effectively implement*** a simple neural network (with single hidden layer), using heuristic "rules of thumb" for selecting appropriate numbers of hidden nodes, and
- ***Describe and demonstrate*** how credit assignment works in a neural network.
- ***Design and develop*** a simple MLP architecture, appropriately selecting:
  - Numbers of hidden nodes for given input / output vector lengths and data set complexity, and
  - Transfer functions for the hidden and output nodes, and
- Further ***describe*** the influence of different parameters in the neural network code on training and performance, ***for more complex classifications***, specifically:
  - "Eta" - the learning rate,
  - "Alpha" - the steepness of the transfer function, and
  - "Epsilon" - the criteria for accepting that the network has been sufficiently trained, and
- ***Develop*** design-and-test methodologies to assess:
  - How hidden node performance correlates with total numbers of hidden nodes for various network configurations, and
  - How hidden node activations correspond with a given input and output training pair.

Required Readings:

- See Canvas.

Assignment A.1 Due at the end of this week.

Sync Session

TBA

Week 3

Deep Neural Networks: Architectures and Design Principles

Learning Objectives

After completing Module 3, the student should be able to:

- ***Identify and describe*** bottlenecks with simple neural networks (MLPs), building on the Week 2 work,
- ***Design*** a classification strategy so that a network can be trained to recognize classes of inputs (and not just specific inputs) via studying how hidden nodes learned to recognize specific features in similar inputs (from Week 3).
- ***Understand*** the overfitting & underfitting issues with multiple layers
- ***Understand*** different regularization methods to mitigate the overfitting & underfitting issues

Required Readings:

- See Canvas.

Sync Session

Python code walkthrough – on the assigned day of the week.
Sync Session attendance is optional. Each Sync Session is recorded.

Week 4

Spatial (Image) Data Processing—Convolutional Neural Networks (CNNs)

Learning Objectives

After completing Module 4, the student should be able to:

- ***Identify*** the kinds of tasks for which Convolutional Neural Networks (CNNs) are used,
- ***Define*** and ***give examples*** of the key CNN terms and concepts,
- ***Describe*** how CNNs operate:
  - How masking filters produce feature-specific inputs,
  - How different CNN architectures achieve specific goals, and
  - How the various hyperparameters work in a CNN architecture, and
- ***Describe*** and ***give examples*** of how CNNs learn to recognize specific kinds of patterns.
- Working with a base program provided by the instructor, conduct CNN tasks and ***appraise and evaluate*** the results, and
- ***Modify*** the program to investigate how performance can be improved via:
  - Different architectures and hyperparameter selection, and
  - Different kinds and numbers of masking fields, and
- ***Appraise and evaluate*** how various training patterns can be grouped into classes, even though they may have differences in pattern location, orientation, etc.,

Required Readings:

- See canvas.

Assignment A.2 Due at the end of this week.

Sync Session

TBA

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Week 5

Temporal Data Processing—Recurrent Neural Networks (RNNs)

Learning Objectives

After completing Module 5, the student should be able to:

- ***Identify*** the kinds of tasks for which Recurrent Neural Networks (RNNs) and other temporal-data-processing networks are used,
- ***Define and give examples*** of the key terms and concepts introduced in this study of neural networks for temporal data processing,
- ***Describe*** how classic temporal-processing neural networks operate:
  - Backpropagation through time,
  - Time-delay neural networks (TDNNs),
  - Recurrent neural networks (RNNs),
  - Long short-term memory networks (LSTM networks), and
  - Other temporal data processing networks
- ***Identify and describe*** different RNN and LSTM architectures, and
- ***Appraise and evaluate*** how RNNs and LSTMs train and operate.
- (Optional:) ***Analyze a time series using a RNN or LSTM network: Experiment with, assess, and appraise and evaluate*** *the results of either a RNN or LSTM network,* working with a base program provided by the instructor, or with a program available as an online resource. (Note that students may, at their discretion, elect to focus on their Final Project. This practicum will be useful if students are doing a Research Project, in lieu of a Coding and Analytics Project.)

Required Readings:

- See Canvas

Assignment A.4 ONLY proposal is Due at the end of this week.

Sync Session

Python code walkthrough – on the assigned day of the week.
Sync Session attendance is optional. Each Sync Session is recorded.

Week 6

Natural Language Processing – RNN's

Learning Objectives

After completing Module 6, the student should be able to:

- ***Describe*** the role of text preprocessing in NLP.
- ***Describe*** how recurrent neural networks (including long short-term memory models) and 1D convolutional neural networks may be employed in natural language processing.
- ***List*** various sequence-to-sequence and sequence-to-word natural language processing applications.
- ***Construct*** natural language processing models using a RNN, LSTM and 1D CNN

Required Readings:

- See Canvas

Assignment A.3 Due at the end of this week.

Sync Session

TBA

Week 7

Deep Generative Learning – Auto Encoders & GAN's

Learning Objectives

After completing Module 7, the student should be able to:

- ***Identify*** and characterize bottlenecks with simple neural networks (MLPs),
- ***Describe*** fundamental strategies for creating effective deep neural networks,
- ***Identify and describe*** architecture and design principles for deep neural networks,
- ***Identify and describe*** useful training strategies for deep neural networks,
- ***Evaluate and select*** appropriate transfer functions for different hidden layers as well as the output layer,
- ***Design*** a neural network architecture that enables generative learning, and
- ***Identify*** how generative learning plays a role in two key applications:
  - Generative Adversarial Networks (GANs), and
  - Autoencoders.

Required Readings / Resources:

- See Canvas

Sync Session

TBA

Week 8

Reinforcement Learning

Learning Objectives

After completing Module 8, the student should be able to:

- ***Identify*** the kinds of tasks for which reinforcement learning is used,
- ***Define and give examples*** of the key terms and concepts introduced in this study of reinforcement learning,
- ***Describe*** how reinforcement learning operates:
  - Describe and give an example of a Markov decision process,
  - Describe how Q-learning works, and
- ***Differentiate*** between (model-free) reinforcement learning and various model-based learning methods (e.g., supervised learning, together with unsupervised learning, and semi-supervised learning).

Required Readings:

- See Canvas

Sync Session

TBA

Week 9

A9: Past, Present, and Future

Learning Objectives:

- ***Define and give examples*** for the ***Week 1 key terms and concepts***,
- ***Differentiate and give examples*** of different representation levels, specifically:
  - Signal/statistical,
  - Syntactic/semiotic, and
  - Symbolic, and
- ***Explain*** how the symbol level is used in AI knowledge representation.

Programming Assignment 1 (Weeks 1 to 3) has the following objectives:

- ***Explore*** *neural nets/seeing how they work on a very simple problem,*
- ***Examine*** *alternative neural net structures with a simple, single-hidden layer network, and*
- ***Learn*** *how to fit a neural network directly in Python (or Scikit Learn, TensorFlow, or Keras).*

This first assignment gives you a choice as to which of these objectives to emphasize.

Required Readings:

- See Canvas.

Sync Session

On the assigned day of the week.
Sync Session attendance is optional. Each Sync Session is recorded.

Week 10

Review and Final Assignment

Learning Objectives

There will be no new material introduced during this week.

Required Readings / Resources:

- No new required readings this week.

Optional Readings / Resources:

- Any optional materials will be found in the Canvas website for this Module

Assignments

- ***A.4 Fourth Research/Programming Assignment:*** AI or Deep Learning (Pick one of many options) (Due at End of Week)

Sync Session

TBA