Ira A. Fulton Schools of Engineering
Arizona State University

Course Syllabus & Schedule – Spring 2021 (Session B)

CSE 598: Introduction to Deep Learning in Visual Computing

Instructor	Hemanth Venkateswara
Teaching Assistants	Paarvendhan Puviyarasu, Nithiya Uppara
Virtual Office Hours	See Live Events section below and course's Live Events page
Content Questions	Weekly discussion forums and live events
Course Issues	Course "Feedback" tool (blue button on every course page)
Technical Support	Coursera Learner Help Center
NOTE:	Please make sure you are logged in with your ASU email address so that support personnel recognize you as an ASU degree student.
Private Support	mcsonline@asu.edu
NOTE:	When sending an email about this class, please include the prefix "CSE 598 DL" in the subject line of your message.
Slack Channel	#spring_b_2021_cse_598_introduction_to_deep_learning_in_visual_computing
NOTE:	This channel is available in the ASU MCS Slack workspace (http://asu-mcsonline.slack.com), which you must join/access using your ASURITE credentials.

~ ***Jump*** to **Course Map** ~

Course Description

In recent years deep learning has revolutionized the field of artificial intelligence. Modern deep neural networks extract patterns in large amounts of data in order to solve very complex real-world problems. In this course, you will learn the basic principles of designing and training deep neural networks with a focus on computer vision. In this course, you will learn the founding principles for training deep neural networks along with techniques to train and optimize them. You learn the principles of CNNs, generative modeling for unsupervised learning and much more.

Specific topics covered include:

- Introduction to visual representation & fundamentals of machine learning
- Neural networks & backpropagation
- Optimization techniques for neural networks
- Modern convolutional neural networks
- Unsupervised learning and Generative models
- Transfer learning

Learning Outcomes

By completing this course, you will be able to:

- Demonstrate an understanding of the mathematics (Statistics, Probability, Calculus, Linear Algebra and optimization) needed for designing neural networks
- Provide examples of hands-on experience building and training neural networks from scratch
- Design deep neural networks for real-world applications in computer vision
- Explain deep learning approaches for unsupervised learning including variational autoencoders (VAE) and generative adversarial networks (GAN)
- Execute the transfer of knowledge across neural networks to develop models for applications with limited data

Estimated Workload/Time Commitment

Average of 18 - 20 hours per week

Required Prior Knowledge and Skills

- High-level programming language (Python with NumPy recommended)
- Familiarity with Jupyter Notebooks
- Familiarity with using a GPU environment for deep learning (such as Google Colab, Kaggle, or your own setup)
- Statistics
- Probability
- Calculus
- Linear Algebra

Technology

Hardware
- No special requirements except a machine with sufficient memory and processing power

Software
- Reliable Internet connection
- Up-to-date web browser
- GPU environment for deep learning such as Google Colab (free), Kaggle (free), or your own setup

Texts

No textbook is required for this course. The following optional texts and readings on deep learning are, however, recommended.

Deep Learning, by Ian Goodfellow, Yoshua Bengio and Aaron Courville
https://www.deeplearningbook.org/

Dive Into Deep Learning, by Aston Zhang, Zachary C. Lipton, Mu Li and Alexander J. Smola
https://d2l.ai/

Deep Learning for Coders with Fastai and Pytorch: AI Applications Without a PhD
https://github.com/fastai/fastbook

Deep Learning with Python, by Francois Chollet
https://www.manning.com/books/deep-learning-with-python

The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, and Jerome Friedman
https://web.stanford.edu/~hastie/Papers/ESLII.pdf

Important Course Dates

Class begins: Monday, March 8, 2021
Holiday(s): No U.S. holidays this term (no planned University closures)
Exam 1: Opens Friday, April 9, 12:15 AM Phoenix; closes/must be completed by Sunday, April 11, 11:45 PM Phoenix (last appointment will be Sunday, April 11, 9:15 PM Phoenix)
Exam 2: Opens Friday, April 30 12:15 AM Phoenix; closes/must be completed by Sunday May 2, 11:45 PM Phoenix (last appointment will be Sunday, May 2, 9:15 PM Phoenix)
Class ends: Sunday, May 2, 2021
Grades due: Monday, May 3, 2021

Course Schedule by Week and Late Work Policies

Unless otherwise noted, **all graded work (assignments, unit quizzes, and exams), is due** at **11:59 PM (AZ)** the **Sunday** ending the **week** for which it is assigned.

Late work: A **10% late penalty** will be added **each day** for graded quizzes and assignments submitted after the scheduled due date. Late exams will **not** be accepted.

The only exceptions will be previously agreed upon disability accommodations, emergencies, or other extenuating circumstances.

~ ***Jump*** to full **Course Map** ~

Week	**Main Topic**	**Begin Date**	**End Date/Graded Work Due**
1	Introduction to Learning Systems and Prerequisites	March 8	March 14
2	Linear Models - Graded Assignment #1	March 15	March 21
3	Multi-layer Neural Networks - Graded Assignment #2	March 22	March 28
4	Optimization - Graded Assignment #3	March 29	April 4
5	Convolutional Neural Networks - Graded Assignment #4	April 5	April 11
5	Exam 1	April 9	April 11
6	Unsupervised Learning - Generative Models - Graded Assignment #5	April 12	April 18
7	Transfer Learning - Graded Assignment #6	April 19	April 25
8	Exam 2	April 26	May 2

Grade Breakdown

Course Work	Quantity	Format	%
Graded quizzes*	7	Individual	20%
Graded assignments	6	Individual	50%
Midterm exam (Weeks 1-4 covered)	1	Individual	15%
Final Exam (Weeks 5-7 covered)	1	Individual	15%

*The system will automatically drop your lowest graded quiz score.

Grade Scale

Consistent with CIDSE policy, you must have a cumulative grade of at least 70% to earn a "C" in and credit for this course. The full list of cutoffs that will be used to generate your letter grade follows:

A+	≥97%
A	≥90%
B+	≥83%
B	≥75%
C	≥70%
D	≥60%
E	<59.9%

NOTE: For more information about grading, visit ASU's Grades & Records webpage.

Course Content

The course comprises the following elements:

Instruction	Assessments
Video Lectures* Readings Live Events/Virtual Office Hours Discussion Forums	Practice "Knowledge Check" quizzes (ungraded) Graded programming assignments (auto- and staff-graded) Graded quizzes (auto-graded)

* Transcript files and PDFs of all lecture slides appear under each video's "Resources"/"Download" tab. Please also see the "Lecture Slides – All Available" reading in Week 1 Getting Started.	Practice exam (auto-graded) Exam 1 & Exam 2 (proctored, auto-graded with staff review)

Assessment Details and Settings

The table below summarizes what you can expect to encounter in the course's assessments.

Spring B 2021 NOTICE: Due to Covid-19 challenges, the time limit for this course's graded quizzes has been eliminated. Please keep in mind that the time limit was in place to give you practice working under time constraints, as exams will be timed.

Content Type	Description	Time Limit	# of Attempts	Feedback
Practice quizzes – Knowledge Checks	Each module includes Knowledge Check practice quizzes, which cover only each module's topic. The system may present a different selection of questions to you after your first attempt. These quizzes do not contribute toward your final score in the class.	None	Unlimited	Full (score, correct/incorrect choices, explanations)
Practice Midterm Exam	The system may present a different selection of questions to you after your first attempt. This practice exam does not contribute toward your final score in the class.	None, but we recommend you enforce one	Unlimited	Full (score, correct/incorrect choices, explanations)
Graded assignments	Weeks 2 - 7 include graded programming assignments. The nature and complexity of these assignments varies. These items appear in sections titled "Graded Assignment #x" that precede the relevant week's graded quiz section. NOTE: The assignments have both auto-graded and staff-graded components. Some of the	None	Unlimited	Auto-graded and staff

Content Type	Description	Time Limit	# of Attempts	Feedback
	assignments require a GPU setup. Students are required to set up their own GPU-supported environments, such as Google Colab, Kaggle, or their own environment. For more information, see “Resources for Graded Assignments” in **Getting Started** (Week 1 in the course).			
Graded quizzes – Unit/Weekly	Units 1-7 include one graded quiz that covers the entire unit and counts toward your final score in the course. NOTE: Your lowest quiz score will be automatically dropped.	60 minutes ***See Spring B 2021 notice above.***	1	Partial (score and correct/incorrect choices)
Exams	You will have two (2) proctored exams, Exam 1 and Exam 2, taken in the course with ProctorU, a live, remote proctoring service that allows students to take exams online while ensuring the integrity of the exam for the institution. Exams are available for three (3) days. Additional information is provided in the Course Map, Week 1’s “Guide to ProctorU and Proctored Exams” (reading in **Getting Started**), exam-specific instructions in Weeks 5 and 8, and the MCS Onboarding Course accessible from your Coursera dashboard).	Midterm: 135 minutes total (2 hours plus 15 minutes start-up with proctor) Final: 135 minutes total (2 hours plus 15 minutes start-up with proctor)	1	Limited (score only)

Live Events and Virtual Office Hours

This course will offer multiple live event and virtual office hour sessions each week, all of which will be hosted on Zoom. These sessions have an open, “drop-in” format to provide everyone an opportunity to meet with the course instructor and/or teaching assistants as well as classmates to ask questions and learn more about course topics and assignments

Live events/virtual office hours may be joined using a computer or a mobile device. iOS devices, however, are not fully supported at this time. To join from an iOS device, use the Zoom app and paste in the event's URL. Using other mobile operating systems or a computer, simply open the Coursera app, navigate to "Live Events," and click the available event link to join.

NOTICE: Due to Zoom security changes effective December 26, 2020, if you are not logged into your ASU account (ASURITE login), you will be put into a meeting waiting room. If you are logged into your ASU account, you should be allowed direct/immediate access to the meeting once it is started by the host.

Instructor Live Event Days and Times
All events will be led by Professor Venkateswara and run for one hour on Fridays. Times shown are Phoenix.

Day	Date/Start Time
Friday	Mar 12, 2021 – 10-11 AM
Friday	Mar 19, 2021 – 10-11 AM
Friday	Mar 26, 2021 – 10-11 AM
Friday	Apr 02, 2021 – 10-11 AM
Friday	Apr 09, 2021 – 10-11 AM
Friday	Apr 16, 2021 – 10-11 AM
Friday	Apr 23, 2021 – 10-11 AM
Friday	Apr 30, 2021 – 10 -11 AM

GSA Virtual Office Hour Days and Times
All events will run for one hour. Times shown are Phoenix.

Day	Start Time	GSA
Monday	3:00 PM	Paar
Tuesday		
Wednesday		
Thursday	10:00 AM	Nithiya
Friday		
Saturday		
Sunday		

Watch for email announcements and check the [Live Events]() page in the course for possible changes to the days and times listed above. URLs for live events/virtual office hours are provided on the course's Live Events page.

Note: The instructor's live events will be recorded and uploaded to the course by the end of the day following each event. Look for the "Live Event Recordings" section at the end of each week.

Graded Quiz and Exam Question Policies

Students will receive a grade for graded quizzes and exams but the questions and answers will not be released, as is the case for other standardized tests such as the GRE and SAT. This policy supports the academic integrity of the course.

We ensure the correctness of the questions, and if we indeed find that any question might be doubtful (which should be extremely rare, since we have many Quality Assurance steps), all students will be given full credit for that question regardless of the answer each selected.

TAs will identify any topic areas that need further discussion and will verbally (without, that is, showing the questions on the screen) discuss them during an office hour. Questions will be discussed at the conceptual level only, specific problems will not be reviewed, and the discussion will focus on common mistakes and misunderstandings.

Students find they can be successful on this course's exams by diligently studying and understanding the topics covered in the lecture videos and practice quizzes, and practice midterm exam, as well as having a full understanding of the topics and techniques applied in the graded assignments.

Other Policies

Academic Integrity: All students in this class are subject to ASU's Academic Integrity Policy (available at http://provost.asu.edu/academicintegrity) and should acquaint themselves with its content and requirements, including a strict prohibition against plagiarism. All violations will be reported to the Dean's office, who maintain records of all offenses. Students are also required to abide by Coursera's Code of Honor. Note further that ASU degree courses on Coursera are integrated with Vericite to verify student work against multiple sources in their proprietary database. Vericite draws from a database of more than 50 million academically related websites and its own repository of previously submitted papers to flag submitted papers with a plagiarism score.

You may discuss with your peers the class materials related to graded coursework but should not discuss the solutions to the problems themselves, nor show any written solution, including a sketch. When you receive help from others, you should acknowledge their help by stating their name or source with your submitted work. Violating these requirements will be considered cheating and will be reported to the Dean's office; furthermore, the assignment grade will be 0 and your letter grade will get lowered by one.

Disability Accommodations: Suitable accommodations will be made for students having disabilities and students should notify the instructor as early as possible if they will require same. Such students must be registered with the Disability Resource Center and provide documentation to that effect.

Sexual Discrimination: Title IX is a federal law that provides that no person be excluded on the basis of sex from participation in, be denied benefits of, or be subjected to discrimination under any education program or activity. Both Title IX and university policy make clear that sexual violence and harassment based on sex is prohibited. An individual who believes they have been subjected to sexual violence or harassed on the basis of sex can seek support, including counseling and academic support, from the university. If you or someone you know has been harassed on the basis of sex or sexually assaulted, you can find information and resources at https://sexualviolenceprevention.asu.edu/faqs.

As mandated reporters, course facilitators are obligated to report any information they become aware of regarding alleged acts of sexual discrimination, including sexual violence and dating violence. ASU Counseling Services, https://eoss.asu.edu/counseling, is available if you wish discuss any concerns confidentially and privately.

Grading Questions: If you believe that there is a mistake in grading, you must inform the facilitator within one week after the graded work was returned to you.

For further ASU and MCS policies and procedures, refer to the [MCS Graduate Handbook].

NOTE: You may also review ASU and MCS policies and procedures in the MCS Student Onboarding course in Coursera.

Course Creator

Hemanth Venkateswara

Hemanth Venkateswara is an Assistant Research Professor at the School of Computing Informatics and Decision Systems Engineering at Arizona State University. He completed his PhD in machine learning and computer vision in 2017 from Arizona State University. Hemanth's research interests include transfer learning, incremental learning and generative models using deep learning. His research explores knowledge transfer paradigms for deep neural networks that are challenging to train due to paucity of annotated data. Hemanth holds a bachelor's degree in Physics and master's degrees in Physics and Computer Science. Prior to his PhD, Hemanth worked as a senior software engineer at Alcatel-Lucent Technologies, India. Hemanth is a member of the IEEE and the ACM.

Course Map – Spring B 2021

WEEK 1 - Unit 1: Introduction to Learning Systems and Prerequisites

Learning Objectives

- Discuss popular deep learning applications in computer vision
- Describe the role of deep neural networks in feature extraction
- Understand Gaussian distributions – univariate and multivariate
- Revise probability prerequisites - sum rule, product rule, Bayes rule, Information, Entropy
- Estimate the derivatives of matrix variables

Modules

Module 1: Introduction to Learning Systems and Prerequisites
Module 2: Evolution of Feature Extraction
Module 3: Review of Essential Prerequisites - Probability

Module 4: Review of Essential Prerequisites – Gaussian Distributions
Module 5: Review of Essential Prerequisites – Matrix Differentiation

To Do

- ❑ Download/print the CSE 598 DL Syllabus and Course Map (this document)
- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ Create your ProctorU account (if you do not already have one)
- ❑ Schedule Exam 1 with ProctorU (see exam details under Week 5 below)
- ❑ If you are registered with SAILS (formerly DRC) and require accommodations, inform the instructor

Due by March 14, 2021

- ❑ Getting Started Quiz
- ❑ Get to Know Your Classmates Discussion Assignment
- ❑ Graded Unit 1 Quiz

WEEK 2 - Unit 2: Linear Models

Learning Objectives

- Derive the least squares solution to linear regression using maximum likelihood
- Identify the power of vectorization
- Extend linear regression to non-linear regression
- Derive a logistic regression model for binary classification
- Understand how the logistic unit is a single layer neural network

Modules
Module 1: Linear Regression
Module 2: Vectorization and Optimization
Module 3: Maximum Likelihood
Module 4: Ridge Regression and Constrained Optimization
Module 5: Nonlinear Regression and Cross Validation
Module 6: Binary Classification and Logistic Neuron

To Do

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ If you haven't yet, schedule Exam 1 with ProctorU (see exam details under Week 5 below)

Due by March 21, 2021

- ❑ Graded Unit 2 Quiz

- ❑ Graded Assignment #1 - Implementing a linear regression model and a binary classifier

WEEK 3 - Unit 3: Multi-layer Neural Networks

Learning Objectives

- Learn the notation for a multi-layer network
- Define the types and roles of different activation functions
- Understand the information flow in the network through forward and back propagation
- Define a modular network layer and design a modularized multi-layer network
- Extend to multi-category classification with softmax and cross-entropy

Modules

Module 1: Layers, Activations and Notations
Module 2: Activation Functions
Module 3: Forward and Back Propagation
Module 4: Modular Layer
Module 5: Softmax and Cross-entropy Loss
Module 6: Derivative for the Softmax and Cross-entropy

To Do

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ If you haven't yet, schedule Exam 1 with ProctorU (see exam details under Week 5 below)

Due by March 28, 2021

- ❑ Graded Unit 3 Quiz
- ❑ Graded Assignment #2 - Implementing a multi-category multi-layer neural network classifier

WEEK 4 - Unit 4: Optimization

Learning Objectives

- Understand how a network I trained using data – the procedure of gradient descent and its variations
- Learn how to initialize the parameters of a network and prepare the data with normalization
- Learn about the role of dropout and batch-norm in training deep neural networks
- Understand the role of hyper-parameters like momentum and learning rate and learn to fine- tune them for efficient training

Modules
Module 1: Batch, Mini-batch and Stochastic Gradient Descent
Module 2: Weight Initialization
Module 3: Data Normalization
Module 4: Batch Norm
Module 5: Regularization
Module 6: Momentum
Module 7: Learning Rate
Module 8: Hyperparameter Tuning

To Do
- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ If you haven’t yet, schedule Exam 1 with ProctorU (see exam details under Week 5 below)
- ❑ Study for Exam 1

Due by April 4, 2021
- ❑ Graded Unit 4 Quiz
- ❑ Graded Assignment #3 - Implementing optimization techniques dropout, momentum and batch norm for training of a multilayer neural network

WEEK 5 - Unit 5: Convolutional Neural Networks

Learning Objectives
- Learn the difference between hand-crafted filter and a CNN trained filter for feature extraction in images
- Describe the components of a CNN – convolution, stride, padding and pooling and
- Understand the notation and derive the formulae to calculate dimensions of the components of a CNN
- Understand the architecture of popular CNNs
- Discuss a few applications of CNNs

Modules
Module 1: Image Filters and Features
Module 2: Convolutional Layer – Stride, Pad
Module 3: Pooling
Module 4: Classic CNN Examples
Module 5: Modern CNN Examples
Module 6: CNN Implementation and Analysis

To Do

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)

Due by April 11, 2021

- ❑ Graded Unit 5 Quiz
- ❑ Assignment #4 - Implementing a Convolutional Neural Network using the pytorch deep learning library
- ❑ Exam 1 *(see below)*

Exam 1 Specifics

Opens: Friday, April 9, 2021, 12:15 AM Phoenix
Closes: Sunday, April 11, 11:45 PM Phoenix*
***Last available appointment: Sunday, April 11, 2021, 9:15 PM Phoenix**

Covers: Weeks (Units) 1 – 4 (25 multiple-choice questions)
Duration: 135 minutes (120 minutes + 15 minutes for start-up with proctor)
Live proctoring: Yes
Grading: Auto-graded with staff review

Allowed Materials:

Notes: One sheet (both sides) of 8.5x11 (or equivalent) paper of **handwritten** notes ***OR*** one side of one sheet of 8.5x11 (or equivalent) of **typed** notes.
Scratch paper: Three sheets (both sides) of 8.5x11 (or equivalent) paper OR a physical dry erase white board, marker, and eraser
Calculator: Separate scientific/graphing calculator or the calculator on your computer or Microsoft Excel

ATTENTION: Use of supplemental electronic devices or software will not be permitted during the exam. No cell phones. No digital whiteboards. No bathroom breaks allowed. **You must destroy your scratch paper or erase your whiteboard at the end of the exam.**

PROCTORU NOTICES:

- ❑ You must schedule your exam at least 72 hours prior to your desired appointment to avoid having to pay a late-scheduling fee.
- ❑ Conduct a ProctorU system test PRIOR to your exam.

WEEK 6 - Unit 6: Unsupervised Learning – Generative Models

Learning Objectives

- Learn to extract patterns (features) from data without any supervision (labels).

- Describe different unsupervised learning techniques like autoencoders, generative adversarial networks (GANs) and variational autoencoders (VAEs).
- Generate new images using generative techniques like GANs and VAEs Discuss modern learning methods in self-supervised learning
- Understand the principles of semi-supervised learning

Modules

Module 1: Autoencoders
Module 2: Sparse, Denoising and Stacked Autoencoders
Module 3: Autoregressive Models
Module 4: Variational Autoencoders
Module 5: Generative Adversarial Networks (GANs)

To Do

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ If you haven't already, schedule Exam 2 with ProctorU (see exam details under Unit 8 below)

Due by April 18, 2021

- ❑ Graded Unit 6 Quiz
- ❑ Assignment #5 - Implementing a Generative Adversarial Network for MNIST dataset

WEEK 7 - Unit 7: Transfer Learning

Learning Objectives

- Understand the concept of transfer learning and the different paradigms of knowledge transfer
- Learn to perform standard knowledge transfer using pre-trained deep networks
- Develop feature alignment procedures to align features from two domains
- Develop image alignment procedures to align data from two domains
- Discuss current approaches to domain adaptation

Modules

Module 1: Transfer learning paradigms
Module 2: Shallow Domain Adaptation
Module 3: Deep Features Domain Adaptation
Module 4: Feature Alignment
Module 5: Image Alignment

To Do

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)

- ❑ If you haven't already, schedule final exam with ProctorU (see exam details under Week 8 below)
- ❑ Study for Exam 2

Due by April 25, 2021

- ❑ Graded Unit 7 Quiz
- ❑ Assignment #6 - Implementing a domain adaptation model transferring knowledge from SVHN dataset to MNIST dataset

WEEK 8 – Exam 2

To Do/Due by May 2, 2021

- ❑ Attend and/or watch recorded Live Event/Virtual Office Hour(s)
- ❑ Study for and take final exam
- ❑ Exam 2 *(see below)*

Exam 2 Specifics
Opens: Friday, April 30, 2021 - 12:15 AM Phoenix
Closes: Sunday, May 2, 11:45 PM Phoenix*
***Last available appointment: Sunday, May 2, 9:15 PM Phoenix**

Covers: Weeks (Units) 5 – 7 (25 multiple-choice questions)
Duration: 135 minutes (120 minutes + 15 minutes for start-up with proctor)
Live proctoring: Yes
Grading: Auto-graded with staff review

Allowed Materials:

Notes: One sheet (both sides) of 8.5x11 (or equivalent) paper of **handwritten** notes ***OR*** one side of one sheet of 8.5x11 (or equivalent) of **typed** notes.
Scratch paper: Three sheets (both sides) of 8.5x11 (or equivalent) paper OR a physical dry erase white board, marker, and eraser
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ATTENTION: Use of supplemental electronic devices or software will not be permitted during the exam. No cell phones. No digital whiteboards. No bathroom breaks allowed. **You must destroy your scratch paper or erase your whiteboard at the end of the exam.**

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- ❑ You must schedule your exam at least 72 hours prior to your desired appointment to avoid having to pay a late-scheduling fee.
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