Education Committee Meeting
April 24, 2020
3:00 PM via Zoom

Zoom link:
https://umd.zoom.us/j/96542027185?pwd=bHpmVjBINzBXYVd2cFhta05GdXFRZz09
Meeting ID: 965 4202 7185
Password: 175311

Agenda:

- Updated course list for the Machine-Learning Specialization – Jacobs
  (REQUIRES VOTE)

- Convert special-topic courses to regular offerings:
  o 498L: Introduction to Deep Learning – Shrivastava
  o 498F: Robotics and Perception – Tokekar
  o 498P: Introduction to Deep Learning – Goldstein
527: COMPUTER SCIENCE MAJOR

History
1. Apr 10, 2020 by Apitchaya Pimpawathin (apimpawa)

Changes saved but not submitted

Viewing: 527 : Computer Science Major
Last approved: Fri, 10 Apr 2020 17:14:27 GMT
Last edit: Tue, 21 Apr 2020 14:11:33 GMT

Proposed Action
Curriculum Change

Program Name
Computer Science Major

Program Status
Active

Effective Term
Fall 2020

Catalog Year
2020-2021

Program Level
Undergraduate Program

Program Type
Undergraduate Major

Delivery Method
On Campus

Departments

<table>
<thead>
<tr>
<th>Department</th>
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<tbody>
<tr>
<td>Computer Science</td>
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Colleges

<table>
<thead>
<tr>
<th>College</th>
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</thead>
<tbody>
<tr>
<td>Computer, Mathematical, and Natural Sciences</td>
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</table>

Program/Major Code
07010, 0701B, 0701C, 0701D

MHEC Inventory Program
Computer Science

Degree(s) Awarded

<table>
<thead>
<tr>
<th>Degree Awarded</th>
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<tbody>
<tr>
<td>Bachelor of Science</td>
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Proposal Contact
Apitchaya Pimpawathin; apimpawa@umd.edu
Program and Catalog Information

Provide the catalog description of the proposed program. As part of the description, please indicate any areas of concentration or specializations that will be offered.

Computer science is the study of computers and computational systems: their application, design, development and theory. Principal areas within computer science include machine learning and data science, cybersecurity and privacy, human-computer interaction, artificial intelligence, programming languages, software engineering, computer systems and networking, algorithms and theory of computing, natural language processing, high-performance and quantum computing, databases systems, bioinformatics, robotics, computer vision, information visualization, and virtual- and augmented-reality systems. A computer scientist is concerned with problem solving. Problems range from abstract questions of what problems can be solved with computers to practical matters such as the design of computer systems that are efficient, secure, and easy for people to use.

Catalog Program Requirements:

Much of the knowledge at the early stage of the degree program is cumulative. To ensure that transfer students start with the appropriate courses, the department offers exemption exams for CMSC131, CMSC132, CMSC216 and CMSC250. Students who have had CS courses prior to starting at Maryland are encouraged to schedule and take exemption exams.

A 'C-' or better must be earned in all major requirements.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH140</td>
<td>Calculus I (see your advisor)</td>
<td>4</td>
</tr>
<tr>
<td>MATH141</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>CMSC131</td>
<td>Object-Oriented Programming I</td>
<td>4</td>
</tr>
<tr>
<td>CMSC132</td>
<td>Object-Oriented Programming II</td>
<td>4</td>
</tr>
<tr>
<td>CMSC216</td>
<td>Introduction to Computer Systems</td>
<td>4</td>
</tr>
<tr>
<td>CMSC250</td>
<td>Discrete Structures</td>
<td>4</td>
</tr>
<tr>
<td>CMSC330</td>
<td>Organization of Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMSC351</td>
<td>Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>STAT4xx</td>
<td></td>
<td>3-4</td>
</tr>
</tbody>
</table>

Upper Level Computer Science Courses

Select five 400 level courses from at least three of the following areas with no more than three courses in a given area: 15

Area 1: Systems

- CMSC411 Computer Systems Architecture
- CMSC412 Operating Systems
- CMSC414 Computer and Network Security
- CMSC417 Computer Networks

Area 2: Information Processing

- CMSC420 Advanced Data Structures
- CMSC421 Introduction to Artificial Intelligence
- CMSC422 Introduction to Machine Learning
- CMSC423 Bioinformatic Algorithms, Databases, and Tools
- CMSC424 Database Design
- CMSC426 Computer Vision
- CMSC427 Computer Graphics
- CMSC470 Introduction to Natural Language Processing

Area 3: Software Engineering and Programming Languages

- CMSC430 Introduction to Compilers
- CMSC433 Programming Language Technologies and Paradigms
- CMSC434 Introduction to Human-Computer Interaction
- CMSC435 Software Engineering
- CMSC436 Programming Handheld Systems

Area 4: Theory

- CMSC451 Design and Analysis of Computer Algorithms
CMSC452  Elementary Theory of Computation
CMSC456  Cryptography
CMSC457  Introduction to Quantum Computing

Area 5: Numerical Analysis
CMSC460  Computational Methods 4
or CMSC466  Introduction to Numerical Analysis I

Upper Level Concentration Requirement 5
Select at least 12 credits of 300-400 level courses from one discipline outside of CMSC  12

Total Credits 63-64

Students also have the option to complete the Cybersecurity Specialization (https://academiccatalog.umd.edu/#cyber), Data Science Specialization (https://academiccatalog.umd.edu/#data), or Machine Learning Specialization

1 Students may fulfill CMSC131, CMSC132, CMSC216 or CMSC250 course requirements by passing proficiency exams before they start the sequence of classes.
2 This course must have prerequisite of MATH141 or higher; cannot be cross-listed with CMSC.
3 At the upper level, students take five (5) 400 level courses from at least three different areas with no more than three courses in a given area. An additional two (2) electives, totaling 6 credits, for the general computer science degree are also required. If students take more than three courses from an area, they will be counted as electives. Students can count one credit winter courses towards the elective requirement, as well as independent research or study with a faculty member, and other courses at the 300 or 400 level.
4 Credit will only be given for CMSC460 or CMSC466.
5 Students must also take at least 12 credits of 300-400 level courses from one discipline outside of CMSC. No course in or cross-listed with CMSC can be counted. An overall 2.0 average must be earned in these courses. Each course must be a minimum of 3 credits. Only 1 special topics or independent study course may be used.

Cybersecurity Specialization

Students looking to pursue the cybersecurity specialization are required to complete the lower level courses (MATH140, MATH141, CMSC131, CMSC132, CMSC216, CMSC250), the additional required courses (CMSC330, CMSC351, MATH/STATXXX and STAT4xx beyond MATH141), and the upper level concentration requirements as detailed above. The difference in the specialization is the upper level computer science courses. Students must fulfill their computer science upper level course requirements from at least 3 areas. 1

Students are required to take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC414</td>
<td>Computer and Network Security</td>
<td>3</td>
</tr>
<tr>
<td>CMSC456</td>
<td>Cryptography</td>
<td>3</td>
</tr>
</tbody>
</table>

Students must choose four courses from:

- CMSC411  Computer Systems Architecture
- CMSC412  Operating Systems
- CMSC417  Computer Networks
- CMSC430  Introduction to Compilers
- CMSC433  Programming Language Technologies and Paradigms
- CMSC451  Design and Analysis of Computer Algorithms

Upper Level Elective Courses: three credits from CMSC3XX or CMSC4XX excluding CMSC330 and CMSC351 1

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
</table>

Total Credits 21-22

1 Students may fulfill an area requirement under the Upper Level Elective Courses requirement. Courses that fall within each area are listed in the General Track degree requirements. The five areas are: Area 1: Systems, Area 2: Information Processing, Area 3: Software Engineering and Programming Languages, Area 4: Theory, and Area 5: Numerical Analysis.

Data Science Specialization

Students looking to pursue the data science specialization are required to complete the lower level courses (MATH140, MATH141, CMSC131, CMSC132, CMSC216, CMSC250), the additional required courses (CMSC330, CMSC351, STAT400 and MATH240), and the upper level concentration requirements as detailed above. The difference in the specialization is the upper level computer science courses. Students must fulfill their computer science upper level course requirements from at least 3 areas. 1

Students are required to take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CMSC320</td>
<td>Introduction to Data Science</td>
<td>3</td>
</tr>
<tr>
<td>CMSC422</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
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</tbody>
</table>
Select one of the following:

- CMSC402: Bioinformatic Algorithms and Methods for Functional Genomics and Proteomics
- CMSC420: Advanced Data Structures
- CMSC421: Introduction to Artificial Intelligence
- CMSC423: Bioinformatic Algorithms, Databases, and Tools
- CMSC425: Game Programming
- CMSC426: Computer Vision
- CMSC427: Computer Graphics
- CMSC470: Introduction to Natural Language Processing

Select one of the following:

- CMSC451: Design and Analysis of Computer Algorithms
- CMSC460: Computational Methods

Select two of the following:

- CMSC411: Computer Systems Architecture
- CMSC412: Operating Systems
- CMSC414: Computer and Network Security
- CMSC417: Computer Networks
- CMSC430: Introduction to Compilers
- CMSC433: Programming Language Technologies and Paradigms
- CMSC434: Introduction to Human-Computer Interaction
- CMSC435: Software Engineering

Total Credits: 21-22

Courses that fall within each area are listed in the General Track degree requirements. The five areas are: Area 1: Systems, Area 2: Information Processing, Area 3: Software Engineering and Programming Languages, Area 4: Theory, and Area 5: Numerical Analysis.

## Machine Learning Specialization

Students looking to pursue the machine learning specialization are required to complete the lower level courses (MATH140, MATH141, CMSC131, CMSC132, CMSC216, CMSC250), the additional required courses (CMSC330, CMSC351, STAT4xx beyond MATH141, and MATH240), and the upper level concentration requirements as detailed above. The difference in the specialization is the upper level computer science courses. Students must fulfill their computer science upper level course requirements from at least 3 areas.

Students are required to take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CMSC320</td>
<td>Introduction to Data Science</td>
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<tr>
<td>CMSC421</td>
<td>Introduction to Artificial Intelligence</td>
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<tr>
<td>CMSC422</td>
<td>Introduction to Machine Learning</td>
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</table>

Select two of the following:

- CMSC426: Computer Vision
- CMSC/AMSC460: Computational Methods
- CMSC/AMSC466: Introduction to Numerical Analysis I
- MATH401: Applications of Linear Algebra
- CMSC470: Introduction to Natural Language Processing
- CMSC474: Introduction to Computational Game Theory
- CMCS498F: Course CMCS498F Not Found (CMCS498F: Robotics and Perception)
- CMSC498L: Course CMSC498L Not Found (CMSC498L: Introduction to Deep Learning)
- CMSC498P: Course CMSC498P Not Found (CMSC498P: Machine Learning Capstone)

Upper Level Elective Courses: six credits from CMSC3XX or CMSC4XX excluding CMSC330 and CMSC351

Total Credits: 21

Students may fulfill an area requirement under the Upper Level Elective Courses requirement. Courses that fall within each area are listed in the General Track degree requirements. The five areas are: Area 1: Systems, Area 2: Information Processing, Area 3: Software Engineering and Programming Languages, Area 4: Theory, and Area 5: Numerical Analysis.
Sample plan. Provide a term by term sample plan that shows how a hypothetical student would progress through the program to completion. It should be clear the length of time it will take for a typical student to graduate. For undergraduate programs, this should be the four-year plan.

<table>
<thead>
<tr>
<th>Semester Year</th>
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<tr>
<td>Freshman Year</td>
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<td>AASP100 (DSHS, DVUP)</td>
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<td>Semester 1</td>
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<td>CMSC330</td>
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<td>Junior Year</td>
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<td>PHIL100 (DSHU)</td>
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<td>GVPT200 (DSHS, DVUP)</td>
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<td>ASTR315 (Upper Level Concentration 1 &amp; DSSP)</td>
<td>ENGL125 (SCIS)</td>
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<td>Senior Year</td>
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<td>CMSC451 (UL CS Elective)</td>
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<td>EDSP476 (Elective)</td>
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<td>PLCY215 (Elective)</td>
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<td>KINES287 (Elective)</td>
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</tbody>
</table>

Total Credits 118

List the intended student learning outcomes. In an attachment, provide the plan for assessing these outcomes.

**Learning Outcomes**

Graduates will be able to create, augment, debug, and test computer software. These skills will be built progressively through the courses in the introductory sequence and in some courses beyond that.

Graduates will develop mathematical and reasoning skills that are needed for computer science.

Graduates will be able to design and implement programming projects that are similar to those seen in the real world.

Graduates will gain skills in communication.

Academic Research (Optional): Graduates will be able to work independently on a project.

**Program Modification Information**

**Linked Programs**

Key: 527
CMSC4XX
Title: Introduction to Deep Learning

Credits: 3
Formerly Offered As: CMSC498L: Introduction to Deep Learning
Formerly Offered in: Spring 2019, Spring 2020

Description:
An introduction to deep learning, a machine learning technique, as well as its applications to a variety of domains. Provides a broad overview of deep learning concepts including neural networks, convolutional neural networks, recurrent neural networks, generative models, and deep reinforcement learning, and an intuitive introduction to basics of machine learning such as simple models, learning paradigms, optimization, overfitting, importance of data, and training caveats. These concepts are understood in the context of advanced applications in computer vision (image classification, object detection, and dense prediction) and natural language processing (sentiment analysis and review classification).

List of prerequisites and/or course restrictions:
Prerequisite: Minimum grade of C- in CMSC330 and CMSC351; and 1 course with a minimum grade of C- from (MATH240, MATH461);
Restriction: Permission of CMNS-Computer Science department. Or must be in (Computer Science (Doctoral), ComputerScience (Master's) program.

Learning Outcomes:
- Acquire the fundamental machine learning concepts that are required to understand and train neural networks. Assessed in the assignments, exams, and final project.
- Understand a variety of neural networks and how they are utilized in different applications. Assessed in the assignments and final project.
- Understanding of the inner workings of state-of-the-art deep learning algorithms and associated machine learning techniques. Assessed in the assignments, exams, and final project.
- Implement and train state-of-the-art deep learning algorithms for computer vision and language processing applications. Assessed in the assignments and final project.

Syllabus:
The course will cover fundamental deep learning techniques, using computer vision and language processing as core applications as a running theme.
- Machine learning basics
  - Simple models: linear and logistic regression
  - Paradigms of learning
- Neural networks basics
  - Terminology, simple neural networks, non-linearities
  - Problem setup, labels, and loss functions
- Optimization basics
  - Loss functions derivatives, local/global minimas
- Gradient descent, stochastic gradient descent
- Training neural networks
  - Initialization, backpropagation
  - Training caveats: overfitting, bias/variance trade-offs
  - Optimization, hyperparameters, and tuning performance
- Convolutional neural networks
  - Task: Image classification
  - Popular architectures, intuitions and key-insights, design principles
  - Visualizing features and neurons, inversion techniques
  - Applications
    - Object detection
    - Dense prediction
- Recurrent neural networks
  - Recurrent architectures, including gated recurrent units and long-short term memory
  - Language modelling, text/language applications
  - Self-attention and transformers
- Advanced topics: vision plus language topics
  - Models, tasks, and training
  - Examples: image captioning, visual question answering
- Advanced topics: image generative models
  - Auto-regressive models
  - Generative adversarial networks, pix2pix, cycleGANs
  - Variational auto-encoders
  - Text-generation, self-supervised learning
- Advanced topics: brief introduction to deep reinforcement learning
- Ethics and bias

Assignments and projects
Assignments explore key concepts and simple applications and will ask students to implement and evaluate neural networks for computer vision and language processing applications as well as evaluate students' background. Example projects:
Assignment 0: Math background: probability, derivatives, vector calculus
Assignment 1: Implement two simple neural networks without using a deep learning library (e.g., using numpy and python): (a) a neural network to do image classification (computer vision), and (b) a neural network to do review classification (language processing).
Assignment 2: Re-implement the neural networks from assignment 2 in a deep learning library (e.g., PyTorch or TensorFlow).
Assignment 3: Write modules for building a convolutional neural network for object detection (basic code structure provided)
Assignment 4: Write modules for building a recurrent neural network for sequence translation (basic code structure provided)
Assignment 5: Write modules for building a neural network for driving a game car using reinforcement learning (basic code structure provided)
Course final project allows an in-depth exploration of a particular application area as chosen by the student. These are performed in groups of 3-5 students.

**Grading scheme:**
40% assignment projects
30% final project
30% exams (1 mid-term, 1 final)
Bonus points for top-N ranks for each challenge assignment.

**Readings:**
The course should be self contained, but if you need additional reading material, you can consult the following:
- Deep learning, Goodfellow, Bengio and Courville, 2016 ([book](https://www.deeplearningbook.org))
- Machine Learning Crash Course, an interactive online course by folks at Google
- Dive into Deep Learning, an interactive online book by folks at Amazon
- Neural Networks and Deep Learning, an online book by Michael Nielsen
**Course Title:** Introduction to Robotics with Perception

**Formerly:** CMSC 498F Robotics and Perception (2016, 2017)

**Description:**
Introduction to the programming of robots with perception. Topics covered include navigation using vision and 3D depth sensors, localization and map making, image processing for visual navigation and recognition, and basic vision and depth-based manipulation. Develop algorithms and learn how to use vision and software tools, such as OpenCV, MoveIt and the Point Cloud Library. Programming is done in Python and C++ under the Robotic Operating System (ROS).

**Additional Course Information:**
The course will be organized around a few projects, starting with navigation in a map, then localization using the map, then finding objects, and finally a project of object manipulation. The software will first be developed in simulation, before testing it on the platform, where students will work in groups.

**Course Prerequisites:** MATH240

**Learning Outcomes:**
1. Ability to implement on a robot path planning and motion control for algorithms for navigation;
2. Understand and use SLAM algorithms based on range sensing;
3. Ability to integrate on a mobile robot the different modules for a complete visual search pipeline

**Syllabus:**

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 1</td>
<td>Introduction, Linear Algebra Review</td>
</tr>
<tr>
<td></td>
<td>Overview of ROS</td>
</tr>
<tr>
<td>Week 2</td>
<td>Hardware and Locomotion</td>
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<td></td>
<td>Coding with ROS</td>
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<tr>
<td>Week 3</td>
<td>Coordinate System Transformations: Representing Position</td>
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<td></td>
<td>and Orientation</td>
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<td></td>
<td>Mobile Robot Kinematics</td>
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<tr>
<td>Week 4</td>
<td>Basic Control and Mobile Robot Control</td>
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<td></td>
<td>Inverse Kinematics</td>
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<tr>
<td>Week 5</td>
<td>Path Planning: Map Representation, Potential Field Methods</td>
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<tr>
<td></td>
<td>Path Planning: Graph Algorithms, Obstacle Avoidance</td>
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<tr>
<td>Week 6</td>
<td>Sensors for Robotics</td>
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<tr>
<td>Week 7</td>
<td>Vision: Image Formation</td>
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<td></td>
<td>Filtering, Edge Detection, Features</td>
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<tr>
<td>Week 8</td>
<td>Vision: Motion Perception</td>
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<tr>
<td></td>
<td>Midterm</td>
</tr>
<tr>
<td>Week 9</td>
<td>Depth from Stereo</td>
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<tr>
<td></td>
<td>Probabilistic Robotics – Statistical Prerequisites</td>
</tr>
</tbody>
</table>
| Week 10 | Uncertainty and Error Propagation  
|         | Localization with Sensors (Markov Localization) |
| Week 11 | Localization with Particle Filters  
|         | Localization with Kalman Filters |
| Week 12 | Depth from Vision: Multiple View Geometry  
|         | 3D Motion Perception |
| Week 13 | Vision: Object Recognition: Specific Objects  
|         | Visual Object Recognition of Object Classes |
| Week 14 | Visual SLAM  
|         | Project Discussion |
| Week 15 | Grasping  
|         | Visual Servoing |
Description
CMSC 43X is a semester-long project course in which each student will identify and carry out a project related to machine learning, with the goal of publishing a research paper or software tool that will benefit their community. Students will...
• Understand machine learning principles and software related to their chosen application area.
• Develop publicly releasable code. Code projects may require
  o Modularity, portability, goog memory management practices
  o Post-processing, restarting, and writing to databases
  o Interactivity
  o Scientific visualization
  o Documentation and version management tools
  o Debugging and profiling tools
  o Validation
• Build verification methods and unit tests

Students will be paired with project advisors from the UMD faculty, or alternatively an industry advisor. Students are encouraged to plan for project results that are publishable at academic conferences, or will impact academic research.

Logistics
Lectures: TBD
Location: TBD
Instructors:
  Tom Goldstein: Irbie 4121

Prerequisites
You must have taken either 421 or 422, and further exposure to machine learning topics is strongly encouraged.

Course requirements
The first semester will have the following deliverables: proposal document, proposal presentation, midterm presentation, final presentation, final report. You will also deliver code and documentation for your project.

Your faculty advisor is required to participate in a meeting with 663 supervisors, and must attend your final presentation.

Grading
This course does NOT have an “A for effort” grading policy. Projects will be graded on the quality of code, documentation, presentation, and writing. Projects that do not meet high standards of quality will not receive an “A”, and in some circumstances will not receive a passing grade.

**Important dates and grading events (tentative)**

Aug 30-Sept 11: Personal presentations
Sept 24: Proposal report and advisor meetings must be completed:
Sept 25 - Oct 11: Proposal presentations
Oct 23-25: Code reviews
Oct 30 - Nov 8: Midterm update presentations
Nov 13 - 15: Code review
Nov 27th - done: final presentations
Dec 10: Final report

**Requirements for deliverables**

Personal presentation (15 mins):
- Where are you from?
- What are you interested in professionally?
- What are you interested in personally?
- What do you hope to get out of this class?

Proposal document and presentation should include:
- Background on the problem: why is it important, what is the state of the art (with citations)?
- Project Goals: what are you hoping to achieve?
- Approach: How will you achieve these goals? What components will need to be implemented to get there?
- Describe specific algorithms and how they will be implemented
- Describe hardware/software platform you target. What programming language?
- How will it be documented and distributed? Github? User guide?
- Validation methods: complete suite of unit tests!
- Deliverables: what specific components/code/data/visualizations will you generate?
- Milestones, and a rough timeline of when you expect to accomplish them?

The oral presentation should last no more than 30 minutes including questions and discussions. A sample presentation document is available. You will be evaluated on the quality of your presentation skills, and clarity of your slides.

The proposal document should be at most 5 pages, and fewer is acceptable.

Midterm update (15 mins):
- Brief overview of project
• Brief overview of approach, goals, milestones
• Update on current status and accomplishments
• Figures or code snippets or demos to show what your code can do
• Explanation and description of any changes/updates to approach

Final Presentation and report (30 mins):
• Build on the proposal and midterm presentations.
• Overview of proposal content
• Detailed description of what has been accomplished and changes to the approach
• Description of what did not get accomplished and why
• Overview of deliverables, such as code, data, code documentation and distribution
• Description of plans for the next semester

Your code must be...
• Well documented, with a user guide (if appropriate)
• Well commented. This includes having descriptive headers and usage information at the top of every file, and having important description information within the code body. Code should also be clearly written, and “self-documenting” when appropriate.
• Well organized, clean, loosely coupled, and extensible
• Portable to different systems
• Thoroughly unit tested and validated
• Distributed using online tools, such as Gitlab, Github, etc...

Academic integrity
Be aware of the UMD code of academic integrity, found here http://www.president.umd.edu/policies/iii100a.html. All sources must be properly and clearly cited. Text or code can never be copied verbatim from the sources, this is plagiarism and a serious offense. You can, of course, import and use third-party libraries in your code (provided you give full and due credit and discuss the third party in your reports and presentations).