PROPOSAL DATE: 2/27/2014

DEPARTMENT: Electrical and Computer Engineering

COURSE DESIGNATOR AND NUMBER: ECE 5424G (CS 5824)

TITLE OF COURSE: Advanced Machine Learning

INSTRUCTOR and/or DEPARTMENTAL CONTACT: Dhruv Batra

CONTACT PHONE: 1-7561

CONTACT E-MAIL: dbatra@vt.edu

Please count this course toward the following scorecard metrics area:
☐ Study Abroad  ☐ Service Learning  ☐ Experiential  ☐ Undergraduate Research

CHECK ONLY ONE OF THE FOLLOWING BOXES

☐ NEW COURSE  ☐ REvised COURSE  [Revision>20%  Revision<20%  ]

☐ NEW COURSE & INCLUSION IN THE CLE  [Area___]  ☐ OTHER:

☐ REvised COURSE FOR INCLUSION IN THE CLE OR CLE AREA CHANGE

Courses routed directly to the University Curriculum Committee For Liberal Education MUST be endorsed by the appropriate Department Head or Dean.

The Chair of the University Curriculum Committee For Liberal Education shall inform the appropriate college curriculum committee of all courses under review by the University Curriculum Committee For Liberal Education.

• A Attach Statement from Dean or Departmental Representative as to whether Teaching this Course will Require or Generate the Need for Additional Departmental Resources.

• B Attach Appropriate Letters of Support from Affected Departments and/or Colleges.

• C Effective Semester: Summer I 2015

• D Change in Title From:

To:

• E Change in Lecture and/or Lab Hours  From: To:

• F Change in Credit Hours  From: To:

• G Percentage of Revision from Current Syllabus: Revision Summary:

• H Course Number(s) and Title(s) to be Deleted from the Catalogue with APPROVAL of course:

APPROVAL SIGNATURES

Department Representative  Date:

College Curriculum Committee Representative  Date:

College Dean  Date:
PROPOSAL DATE: 2/27/2013  
18-DAY REVIEW END DATE: 

DEPARTMENT: Electrical and Computer Engineering 

COURSE DESIGNATOR AND NUMBER: ECE 5424G 

TITLE OF COURSE: Advanced Machine Learning 

TRANSCRIPT (ADP) TITLE (MAX-30 Characters): Advanced Machine Learning 

INSTRUCTOR and/or DEPARTMENTAL CONTACT: Dhruv Batra 

CONTACT PHONE: 1-7561  
CONTACT E-MAIL: dbatra@rt.edu 

Please count this course toward the following scorecard metrics area: 

- Study Abroad  
- Service Learning  
- Experiential  
- Undergraduate Research 

CHECK ONLY ONE OF THE FOLLOWING BOXES 

☐ NEW COURSE  
☐ REVISED COURSE [Revision>20%  
Revision<20%]  

☐ NEW COURSE & INCLUSION IN THE CLE [Area_____]  
☐ OTHER: 

Include Attachment, if Needed 

☐ REVISED COURSE FOR INCLUSION IN THE CLE OR CLE AREA CHANGE 

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☐ C Effective Semester: Fall 2014 

☐ D Change in Title From: 

To: 

☐ E Change in Lecture and/or Lab Hours From: 

To: 

☐ F Change in Credit Hours From: 

To: 

☐ G Percentage of Revision from Current Syllabus: 

Revision Summary: 

☐ H Course Number(s) and Title(s) to be Deleted from the Catalogue with APPROVAL of course: 

APPROVAL SIGNATURES 

Department Representative 

Date: 2/27/14 

College Curriculum Committee Representative 

Date: 3/21/14 

College Dean 

Date: 3/21/14 

Rev 04-20-2012
Advanced Machine Learning
ECE 5424G / CS 5824

I - Catalog Description

Algorithms and principles involved in machine learning; focus on perception problems arising in computer vision, natural language processing and robotics; fundamentals of representing uncertainty, learning from data, supervised learning, ensemble methods, unsupervised learning, structured models, learning theory and reinforcement learning; design and analysis of machine perception systems; design and implementation of a technical project applied to real-world datasets (images, text, robotics).
Pre: Graduate Standing (3H, 3C).

Course Number: 5424G (CS 5824)

ADP TITLE: Advanced Machine Learning

II - Learning Objectives

Having successfully completed this course, the student will be able to:

- Analyze and contrast broad classes of machine learning algorithms (supervised vs. unsupervised vs. semi-supervised)
- Describe and apply fundamental concepts of learning from data (maximum likelihood estimation, maximum a posteriori, overfitting vs underfitting, regularization, cross-validation)
- Explain and program supervised learning algorithms for regression (e.g. least squares via pseudo-inverse)
- Explain and program supervised learning algorithms for classification (e.g. logistic regression via gradient descent, support vector machines via Quadratic Programming)
- Describe and program unsupervised learning algorithms for clustering (e.g. k-means)
- Design and implement a technical project, and apply developed techniques to real-world datasets (images, text, robotics, etc.)
- Apply and adapt learned machine learning techniques to their own research/thesis domain

III - Justification

- Reason for Teaching the Course:

We are witnessing an explosion in data – from billions of images shared online to
Petabytes of tweets, medical records and GPS tracks, generated by companies, users and scientific communities. Applications of machine learning and perception are increasing rapidly as more techniques are developed and implemented to address a wide range of scientific and societal problems. Many universities are expanding programs in machine learning and perception, and employers are increasingly recognizing the importance of such knowledge. Students trained in a deeper understanding of machine learning techniques will be better equipped to make fundamental contributions to research in machine learning, and applied areas such as perception (vision, text, speech), robotics, bioinformatics, etc.

ECE, STAT, CS, and CoS have engaged in discussions regarding potential overlap with CMDA 4854. The overlap in topics is estimated to be \( \leq 30\% \), and the two courses are complementary. Specifically, ECE 5424G has a significant implementation component, with every homework containing an implementation question and a semester-long technical design and implementation project. Students in ECE 5424G will be implementing "from scratch" and not simply using pre-packed software, thus expected to have background in data-structures and algorithms. A support letter from STAT is attached.

- Level Justification:

This course will apply extensive and in-depth knowledge from data structures, algorithms, probability, and statistics, as covered in undergraduate ECE/CS courses. The implementation of these concepts in working systems will be reviewed at the corresponding technical level. Graduate students will benefit by gaining a thorough understanding of machine learning and perception, allowing them to make more fundamental contributions to their research.

ECE 4424 and ECE 5424G are the conjoined courses. While the lectures will be co-located and identical, the HW assignments, quizzes, exams, and project will be level differentiated – ECE 5424G students will be assigned more advanced theory and implementation problems. ECE 4424 students will work on a class project that will focus more on design and implementation of a working system (without regard for novelty), while ECE 5524G students will work on a research-oriented class project, with an emphasis on understanding and making improvements to state-of-the-art machine learning algorithms.

**IV - Prerequisites and Corequisites**

Prerequisites: Graduate Standing

**V - Texts and Special Teaching Aids**
A. Required Text:


B. Recommended Texts:

Handouts and publication readings as assigned by the Instructor. Examples:

VI - Syllabus

<table>
<thead>
<tr>
<th>Topic</th>
<th>Percent of Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Overview of Machine Learning &amp; Perception</td>
<td>5%</td>
</tr>
<tr>
<td>a) Learning from data</td>
<td></td>
</tr>
<tr>
<td>b) Overfitting, regularization, cross-validation</td>
<td></td>
</tr>
<tr>
<td>2. Supervised Learning</td>
<td>25%</td>
</tr>
<tr>
<td>a) Nearest Neighbor</td>
<td></td>
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<tr>
<td>b) Naive Bayes</td>
<td></td>
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<tr>
<td>c) Logistic Regression</td>
<td></td>
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<tr>
<td>d) Support Vector Machines</td>
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<tr>
<td>e) Neural Networks</td>
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</tr>
<tr>
<td>f) Decision Trees</td>
<td></td>
</tr>
<tr>
<td>3. Unsupervised &amp; Semi-Supervised Learning</td>
<td>10%</td>
</tr>
<tr>
<td>a) Clustering (K-means, GMMs)</td>
<td></td>
</tr>
<tr>
<td>b) Factor Analysis (PCA, LDA)</td>
<td></td>
</tr>
<tr>
<td>4. Learning Theory</td>
<td>10%</td>
</tr>
<tr>
<td>a) Bias and Variance</td>
<td></td>
</tr>
<tr>
<td>b) Probably Approximately Correct (PAC) Learning</td>
<td></td>
</tr>
</tbody>
</table>
5. Structured Models
   a) Bayesian Networks
   b) Hidden Markov Models

6. Reinforcement Learning

7. Applications of ML to Perception
   a) Vision
   b) Natural Language Processing

8. Design and implementation of a technical project

100%
Feb. 24, 2014

TO: CoE Graduate Curriculum Committee

FROM: Dr. J. De La Ree, ECE Assistant Department Head

SUBJECT: New Course Proposal for ECE 5424G

Attached is a new course proposal for ECE 5424G Advanced Machine Learning. This course will be conjoined with ECE 4424 Machine Learning.

With the approval of this new course, no additional resources will be required for the ECE Department.

If you have any questions regarding this course proposal, please contact me.

Attachment:
Course proposal: ECE 5424G
December 7, 2014

To Whom It May Concern:

The Department of Computer Science supports cross-listing ECE 5424G "Advanced Machine Learning", as proposed by Dr. Dhruv Batra, with CS 5824.

Sincerely,

[Signature]

Dr. Barbara Ryder
J. Byron Maupin Professor of Engineering
Head, Department of Computer Science
Virginia Tech