ECE 765: Probabilistic Graphical Models for Signal Processing and Computer Vision

In Workflow

1. 14ECE GR Director of Curriculum (dgyu@ncsu.edu; pault@ncsu.edu)
2. COE CC Coordinator GR (rfillin@ncsu.edu)
3. COE CC Chair GR (john_classen@ncsu.edu)
4. COE Final Review GR (rfillin@ncsu.edu)
5. COE Dean GR (reeves@csc.ncsu.edu)
6. ejlobato (ejlobato@ncsu.edu)
7. ABGS Coordinator (mlnosbis@ncsu.edu)
8. ejlobato (ejlobato@ncsu.edu)
9. ABGS Meeting (mlnosbis@ncsu.edu)
10. ABGS Chair (mlnosbis@ncsu.edu)
11. Grad Final Review (mlnosbis@ncsu.edu)
12. PeopleSoft (none)

Approval Path

   Donna Yu (dgyu): Approved for 14ECE GR Director of Curriculum
   Robyn Fillinger (rfillin): Approved for COE CC Coordinator GR
   John Classen (john_classen): Approved for COE CC Chair GR
   Robyn Fillinger (rfillin): Approved for COE Final Review GR
5. Thu, 30 Mar 2017 01:42:18 GMT
   Douglas Reeves (reeves): Approved for COE Dean GR
6. Mon, 17 Apr 2017 14:01:57 GMT
   Edgar Lobaton (ejlobato): Approved for ejlobato
7. Mon, 17 Apr 2017 14:30:16 GMT
   Melissa Nosbisch (mlnosbis): Approved for ABGS Coordinator
   Edgar Lobaton (ejlobato): Approved for ejlobato
9. Fri, 28 Apr 2017 17:40:33 GMT
   Melissa Nosbisch (mlnosbis): Approved for ABGS Meeting

New Course Proposal

Date Submitted: Tue, 28 Mar 2017 13:20:59 GMT

Viewing: ECE 765: Probabilistic Graphical Models for Signal Processing and Computer Vision

Changes proposed by: ejlobato

Change Type
Major

Course Prefix
ECE (Electrical and Computer Engineering)

Course Number
Cross-listed Course
No

Title
Probabilistic Graphical Models for Signal Processing and Computer Vision

Abbreviated Title
Probabilistic Graphical Models

College
College of Engineering

Academic Org Code
Electrical & Computer Engineering (14ECE)

CIP Discipline Specialty Number
14.1001

CIP Discipline Specialty Title
Electrical and Electronics Engineering

Term Offering
Fall Only

Year Offering
Offered Every Year

Effective Date
Fall 2017

Previously taught as Special Topics?
Yes

Number of Offerings within the past 5 years
2

<table>
<thead>
<tr>
<th>Course Prefix/Number</th>
<th>Semester/Term Offered</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE792</td>
<td>Fall 2016</td>
<td>29</td>
</tr>
<tr>
<td>ECE792</td>
<td>Fall 2015</td>
<td>35</td>
</tr>
</tbody>
</table>

Course Delivery
Face-to-Face (On Campus)

Grading Method
Graded/Audit

Credit Hours
3

Course Length
16 weeks

Contact Hours
(Per Week)

<table>
<thead>
<tr>
<th>Component Type</th>
<th>Contact Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Is Repeatable for Credit

No

Instructor Name

Edgar Lobaton

Instructor Title

Assistant Professor

Grad Faculty Status

Assoc

Anticipated On-Campus Enrollment

Open when course_delivery = campus OR course_delivery = blended OR course_delivery = flip

<table>
<thead>
<tr>
<th>Enrollment Component</th>
<th>Per Semester</th>
<th>Per Section</th>
<th>Multiple Sections?</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>35</td>
<td>35</td>
<td>No</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Course Prerequisites, Corequisites, and Restrictive Statement

Programming experience (MATLAB, C++ or other object oriented language such as Python), linear algebra (MA 405 or equivalent), and probability (ECE 514, equivalent or instructor permission).

Is the course required or an elective for a Curriculum?

No

Catalog Description

Techniques for machine learning using probabilistic graphical models. Emphasis on Bayesian and Markov networks with applications to signal processing and computer vision.

Justification for new course:

There are a number of applications in signal processing that make use of probabilistic graphical models. Tools such as Hidden Markov Models and Bayesian Networks are standard tools for researchers. This course aims to give the students a better understanding of these tools so they can properly apply them to their various research areas. These topics are brought up in courses such as pattern recognition in the ECE department, but they do not go into the level of detail specified here including computationally efficient approaches for inference and learning.

Does this course have a fee?

No

Consultation

<table>
<thead>
<tr>
<th>College(s)</th>
<th>Contact Name</th>
<th>Statement Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>College of Sciences</td>
<td>John Blondin</td>
<td>COS does not have any comments or concerns regarding this action. -John</td>
</tr>
</tbody>
</table>

Instructional Resources Statement

Dr. Lobaton will be teaching this course once a year as part of his regular course load. If demand for the course drops, then the course will be taught every other year.
Course Objectives/Goals

This course will cover the fundamentals of probabilistic graphical models. The students will learn about Bayesian network representations and undirected graphical models, and how to perform inference and learning using these representations. Students will learn to apply these techniques to signal processing and computer vision.

Student Learning Outcomes

By the end of this course, the students will be able to:

1. Explain and implement strategies for model assessment
2. Apply standard machine learning approaches for classification and regression in data streams and at the pixel-level in images
3. Explain the basic concepts behind Bayesian Networks, Markov Networks, Dynamic Bayesian Networks, and Hidden Markov Networks
4. Explain the concepts behind exact and approximate inference in graphical models
5. Explain how parameter estimation and structure learning is done for graphical models
6. Train and apply graphical models for applications on signal processing and computer vision

Student Evaluation Methods

<table>
<thead>
<tr>
<th>Evaluation Method</th>
<th>Weighting/Points for Each</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework</td>
<td>30</td>
<td>There will individual biweekly homework assignments, which will require some programming and mathematical derivations. The final homework grade will be computed by averaging all assignments.</td>
</tr>
<tr>
<td>Quizzes</td>
<td>30</td>
<td>There will be biweekly in-class quizzes. They will be approximately 15-minutes long. The final grade will be computed by averaging all scores after dropping the lowest grade.</td>
</tr>
<tr>
<td>Project</td>
<td>40</td>
<td>There will be two group projects, one of which will focus on time series and the other on computer vision. The objective of these projects will be to gain experience applying existing graphical model toolboxes to solving projects in the specific subject areas. Students will implement a baseline approach using standard machine learning techniques, and then compare their results against their implementations using graphical models. Grading will be based on the instructor's review of the reports, performance of the code provided by the teams, and peer reviews of their technical reports.</td>
</tr>
</tbody>
</table>

Topical Outline/Course Schedule

<table>
<thead>
<tr>
<th>Topic</th>
<th>Time Devoted to Each Topic</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overview of Probability and Machine Learning</td>
<td>2</td>
<td>The basic concepts from probability theory and machine learning will be presented. Model Assessment will be discussed as well.</td>
</tr>
<tr>
<td>Bayesian Networks</td>
<td>2</td>
<td>Introduction to the concepts of Bayesian networks.</td>
</tr>
<tr>
<td>Template and Dynamical Bayesian Networks</td>
<td>1</td>
<td>Topics will include Hidden Markov Models and Kalman filtering.</td>
</tr>
<tr>
<td>Undirected Graphical Models</td>
<td>2</td>
<td>Introduction to Markov networks.</td>
</tr>
<tr>
<td>Exact Inference</td>
<td>2</td>
<td>Techniques such as variable elimination will be introduced and Clique Trees.</td>
</tr>
<tr>
<td>Approximate Inference</td>
<td>1</td>
<td>Techniques such as Belief Propagation and Markov Chain Monte Carlos Sampling Methods will be studied.</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Parameter Estimation</td>
<td>2</td>
<td>Maximum Likelihood Estimation and Bayesian Estimation will be studied.</td>
</tr>
<tr>
<td>Structure Learning</td>
<td>1</td>
<td>Techniques for learning structures within graphical models.</td>
</tr>
<tr>
<td>Applications to Signal Processing</td>
<td>2</td>
<td>Applications to physiological signal processing and computer vision will be presented.</td>
</tr>
</tbody>
</table>

**Syllabus**

Syllabus_Updated2 (1).doc

**Additional Documentation**

**Additional Comments**

minosbis 4/3/2017: Suggest consultation with College of Sciences. Contact Dr. John Blondin (john_blondin@ncsu.edu) to arrange consultation and enter consultation summary in the consultation field.

1) Catalog description on the CIM form should match that in the syllabus. This is what will be used for the SIS catalog description.
2) Office hours should be listed on the syllabus
3) Topical outline should be listed on the syllabus

piharrie - 4/3/17 - so are their quizzes or tests (see Student Evaluation section)? There should also be a much clearer description of what the projects will entail even if the topics aren't specifically known. What are the projects designed to accomplish?

**ABGS Reviewer Comments:**

- Syllabus shows 13 week length
- Cost of books is needed on syllabus
- Breakdown of weights for assessment could be more detailed.
- Concern about overlap with Statistics. Consultation with Statistics indicated no overlap. This seems like a very good course and while it is mostly a statistics course, the ST program does not have plans to offer a similar one.

Edgar Lobaton (ejlobato) - 4/26/17

- All above items have been addressed
- Syllabus has been updated to add up to 15 weeks
- Cost of book has been updated in Syllabus
- More details on break down of grading have been added

**Course Reviewer Comments**

dgyu (Mon, 27 Mar 2017 22:33:21 GMT): Rollback: Rollback so that changes can be made.

Key: 14950