**UNIVERSITY OF NEBRASKA AT OMAHA**
**COURSE SYLLABUS/DESCRIPTION**

| | |
|---|---|
| Department and Course Number | CSCI 4470 |
| Course Title | Pattern Recognition |
| Course Coordinator | Qiuming Zhu |
| Total Credits | 3 |
| Repeat for Credit? | No |
| Date of Last Revision | October 10, 2014 |

## 1.0 Course Description Information

1.1 Catalog description:

The purpose of this course is to introduce students to the structures and problems of pattern recognition. This course introduces the problems and computational structures of digital pattern recognition. It covers the mathematical models of statistical and neural nets classifiers. Topics include multivariate probabilities, Bayesian decision theory, maximum likelihood estimation, whitening transformations, parametric and non-parametric pattern classification techniques, linear discriminate functions, gradient-descent procedures, clustering and unsupervised learning, feature selection algorithms, and neural networks for pattern classification.

1.2 Prerequisites of the course:

CSCI 1620, MATH/CSCI 2030

1.3 Overview of content and purpose of the course

This course is intended for senior and selected junior undergraduate students in computer science and related areas. Contents to be covered in this course include:

- To learn the fundamental concepts and methodology of statistical pattern recognition
- To learn the applications to real-world problems in computer vision, remote sensing, medical diagnosis, business decision making, etc.

Primary knowledge in the following areas is to be applied in the course:

- Algorithm design and implementation in a high-level language (like C++)
- Elementary data structures (arrays, stacks, queues, lists, trees)
- Basic linear algebra, simultaneous equations, vector spaces

1.4 Unusual circumstances of the course:

None

## 2.0 Course Justification Information

2.1 Anticipated audience / demand:
Anticipated audiences of this course are senior and selected junior undergraduate students in computer science and computer engineering majors and related areas to fulfill the elective course requirement.

2.2 Indicate how often this course will be offered and the anticipated enrollment:

The course is to be offered once every two years in the fall of even year. Anticipated enrollment is about 16-20 students for each offering.

2.3 If it is a significant change to an existing course, please explain why it is needed:

Not Applicable

## 3.0 List of performance objectives stated in learning outcomes in a student's perspective:

3.1 Students will demonstrate the ability to construct a pattern recognition system architecture with explanation of major components.

3.2 Students will be able to apply linear algebra and statistical methods to form a basic solution approach and algorithms for a pattern recognition problem.

3.3 Students will identify, apply and evaluate modern pattern recognition technologies to a real world application problem.

3.4 Students will gain a basic knowledge and understanding of pattern recognition as a particular area of artificial intelligence, and gain a technical skill for more advanced study and research in pattern recognition.

## 4.0 Content and Organization Information

4.1 List the major topics central to this course

| | | Contact hours |
|---|---|---|
| 4.1.1 | Introduction to pattern recognition | 3.0 |
| | 4.1.1.1. An introductory example of pattern recognition | |
| | 4.1.1.2. Pattern classification machine model | |
| 4.1.2 | Mathematics of statistical pattern recognition | 9.0 |
| | 4.1.2.1. Random vector | |
| | 4.1.2.2. Probability distribution and density function of random vector | |
| | 4.1.2.3. Expectation and co-variance matrices, characteristic functions | |
| | 4.1.2.4. Normal distributions | |
| | 4.1.2.5. Diagonalization of matrices | |
| | 4.1.2.6. Whitening transformation | |
| 4.1.3 | Parametric pattern recognition | 6.0 |
| | 4.1.3.1. Bayesian decision rule and Bayesian decision theory | |
| | 4.1.3.2. Minimization of the probability of error | |
| | 4.1.3.3. Linear discrimination as sub-optimal for normal distributions | |
| | 4.1.3.4. Maximum likelihood decision rule | |
| 4.1.4 | Estimating the probability parameters and density function | 3.0 |
| | 4.1.4.1. Estimating the parameters from samples | |
| | 4.1.4.2. Parzen window estimating of density function | |
| 4.1.5 | Non-parametric technique | 6.0 |
| | 4.1.5.1. Fisher'slinear discriminant function | |
| | 4.1.5.2. Generalization of linear discriminant function | |
| | 4.1.5.3. The gradient descent procedures | |
| | 4.1.5.3.1. The perceptron algorithm | |
| | 4.1.5.3.2. The relaxation algorithm | |
| | 4.1.5.3.3. Ho-kashyap algorithm | |
| | 4.1.5.4. Potential function method | |

4.1.6 Clustering and unsupervised learning 3.0
4.1.6.1. Clustering algorithms
4.1.6.2. Estimation of joint distribution function
4.1.7 Feature selection algorithms 3.0
4.1.7.1. Projection to one dimension method
4.1.7.2. Karhunen-Loeve expansion
4.1.7.3. Fukunaga-Koontz transformation
4.1.7.4. Hotelling trace transformation
4.1.8 Neural network approach for pattern recognition 9.0
4.1.8.1. Neural Network Basics
4.1.8.2. Backpropagation Learning
4.1.8.3. Associative Memory Approach

**5.0 Teaching Methodology Information:**

5.1 Methods:

The primary teaching methods include lectures, homework assignment, examinations, and term projects.

5.2 Student role:

Students will be expected to attend lectures, participate in class room discussions, complete homework and programming assignments on time, take examinations.

**6.0 Evaluation Information**

6.1 Describe the typical types of student projects that will be the basis for evaluating student performance:

Student projects for evaluation include written homework problems, middle-term and final examinations, programming assignments, and an individual research term project that engages the student in a study and experimentation of a theoretical problem or a practical application of pattern recognition. A project proposal, a middle-term written report and a semester final written project report is required for the student. Project oral presentation will be arranged during the middle and final stages of the semester.

6.2 Describe the typical basis for determining the final grade (e.g. weighting of various student projects):

Basis for determining the final grade (Course requirements and grading standards) is as the following;

| Component | Weight |
|---|---|
| Programming Assignment | 25% |
| Intermediate Exams | 20% |
| Final Exam | 25% |
| Term project | 30% |

6.3 Grading type:

The following is the possible grading scale and criteria based on accumulated grade points from 6.2:

| Points | Grade |
|---|---|
| 97-100% | A+ |
| 93-96% | A |
| 90-92% | A– |
| 87-89% | B+ |
| 83-86% | B |
| 80-82% | B– |
| 77-79% | C+ |
| 73-76% | C |
| 70-72% | C– |
| 67-69% | D+ |
| 63-66% | D |
| 60-62% | D– |

## 7.0 Resource Material Information

7.1 Textbooks and/or other required readings used in course

Duda, Hart, and Stork, *Pattern Classification*, 2nd edition, John Wiley & Sons, Inc., 2001

7.2 Other student suggested reading materials:

1. Schalkoff, *Pattern Recognition*, John Wiley & Sons, Inc, 1992
2. Looney, *Pattern Recognition Using Neural Networks*, Oxford Press, 1996
3. Nadler and Smith, *Pattern Recognition Engineering*, John Wiley & Sons, 1992
4. Therrien, *Decision, Estimation, and Classification: An Introduction to Pattern Recognition and Related Topics*, John Wiley & Sons, 1989
5. Duda and Hart, *Pattern Classification and Scene Analysis*, Wiley, 1973
6. Fukunaga, *Introduction to Statistical Pattern Recognition*, Academic Press, 1972

7.3 Current bibliography and other resources:

1. *IEEE Transactions on Pattern Analysis and Machine Intelligence*
2. *International Journal of Pattern Recognition, Pergamon Press*
3. *Pattern Recognition Letters, Elsevier Science Publisher*
4. *Journal of Computer Vision and Image Understanding, Academic Press*
5. *Proceedings of the International Conference on Pattern Recognition*

## 8.0 Other Information

8.1 Accommodations statement:

*N/A*

8.2 Other:

*N/A.*

8.3 Author(s):

Qiuming Zhu

## 9.0 Computer Science Accreditation Board (CSAB) Category Content (class time in hours)

| *CSAB Category* | *Core* | *Advanced* |
|---|---|---|
| Data structures | 2.0 | 3.0 |
| Computer organization and architecture | 2.0 | 4.0 |
| Algorithms and software design | 12.0 | 12.0 |
| Concepts of programming languages | 5.0 | 5.0 |

## 10.0 Oral and Written Communications

Every student is required to submit at least __1___ written reports (not including exams, tests, quizzes, or commented programs) to typically __15___ pages and to make __0___ oral presentations of typically __0___ minutes duration. Include only material that is graded for grammar, spelling, style, and so forth, as well as for technical content, completeness, and accuracy.

## 11.0 Social and Ethical Issues

No coverage

## 12.0 Theoretical content

| | Contact hours |
|---|---|
| 12.1. Mathematics of statistical pattern recognition | 6.0 |
| 12.2. Parametric pattern recognition | 6.0 |
| 12.2.1. Bayesian decision rule and Bayesian decision theory | |
| 12.2.2. Minimization of the probability of error | |
| 12.2.3. Linear discrimination as sub-optimal for normal distributions | |
| 12.2.4. Maximum likelihood decision rule | |
| 12.3 Neural network approach for pattern recognition | 3.0 |
| 12.3.1. Neural Network Basics | |
| 12.3.2. Backpropagation Learning | |
| 12.3.3. Associative Memory Approach | |

## 13.0 Problem analysis

Students will learn to analyze the structures and problems of pattern recognition, the problems and computational structures of digital pattern recognition.

## 14.0 Solution design

Students will apply the technology to solve problems, such as, speech recognition, perception and prediction problems.

## CHANGE HISTORY

| ***Date*** | ***Change*** | ***By whom*** | ***Comments*** |
|---|---|---|---|
| 09/09/2002 | Initial ABET version | Zhu | |
| 06/13/2003 | Cleanup | Wileman | |
| 10/13/2008 | Insertion of table mapping course objectives to program outcomes | Qiuming Zhu | |

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|---|---|---|---|
| 10/10/2014 | (1) Revised contents in new syllabus format; (2) revised mapping of course objectives to program outcomes | Qiuming Zhu | |

**S – Strong relationship**
**X – Contributing relationship**

| **Course objective** | **(a) knowledge of discipline** | **(b) analyze problem, define requirements** | **(c) design and implement solution** | **(d) function on a team** | **(e) ethical issues** | **(f) communicate effectively** | **(g) analyze impact of computing** | **(h) continued professioanl development** | **(i) Current techniques and tools** | **(j) apply foundations** | **(k) apply design and development principles** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Study of the System architecture of pattern recognition | S | S | X | | | | X | | X | | X |
| 2. Study of the mathematic foundations of pattern recognition | X | | | | | | | | X | S | |
| 3. Study of algorithms and techniques for supervised learning in pattern recognition | S | X | X | | | | | | | | X |
| 4. Study of algorithms and techniques for unsupervised learning in pattern recognition | S | X | X | | | | | | | | X |
| 5. Study the statistical methods for problem solving in pattern recognition | X | | | | | | | | X | S | |
| 6. Study of algorithmic approaches for problem solving in practical applications of pattern recognition | S | X | X | | | | | | | | X |
| 7. Study the Neural Networks technology for pattern recognition | S | X | X | | | | | | | | X |
| 8. Study the Bayes theory and Bayesian approaches in pattern recognition | X | | X | | | | | | | | X |
| 9.. Practice of pattern recognition problem solving in term project | | S | S | | X | X | X | X | X | S | S |

**CS Program Outcomes (2008)**

(a) An ability to apply knowledge of computing and mathematics appropriate to the discipline;
(b) An ability to analyze a problem, and identify and define the computing requirements appropriate to its solution;
(c) An ability to design, implement and evaluate a computer-based system, process, component, or program to meet desired needs;
(d) An ability to function effectively on teams to accomplish a common goal;
(e) An understanding of professional, ethical, legal, security, and social issues and responsibilities
(f) An ability to communicate effectively with a range of audiences
(g) An ability to analyze the local and global impact of computing on individuals, organizations and society
(h) Recognition of the need for, and an ability to engage in, continuing professional development
(i) An ability to use current techniques, skills, and tools necessary for computing practices
(j) An ability to apply mathematical foundations, algorithmic principles, and computer science theory in the modeling and design of computer-based systems in a way that demonstrates comprehension of the tradeoffs involved in design choices
(k) An ability to apply design and development principles in the construction of software systems of varying complexity.