University of Macau
Computer and Information Science Department
SFTW424 Introduction to Pattern Recognition
Syllabus
1st Semester 2012/2013
Part A – Course Outline

Elective course in Computer Science

Catalog description:
(3-2) 4.5 credits. This course introduces the fundamentals of pattern recognition for senior undergraduate students. It emphasizes the general principles and techniques of pattern recognition. Topics include classifiers based on Bayes decision theory, linear classifiers, nonlinear classifiers, feature selection, feature generation, template matching, context-dependent classification, supervised learning and system evaluation, unsupervised learning and clustering algorithms. This course will also discuss recent applications of pattern recognition.

Course type:
Theoretical with substantial laboratory/practice content

Prerequisites:
MATH103, MATH111, SFTW360

Textbook(s) and other required material:
- Sergios Theodoridis, *Pattern Recognition*, 4th edition, Elsevier, 2009.

Major prerequisites by topic:
1. Basic knowledge in multi-variables Calculus and Engineering Mathematics.
2. Basic knowledge in Linear Algebra.
3. Fundamentals of Probability theory and Statistics.
4. Programming knowledge of MATLAB or C+.

Course objectives:
1. Learn the fundamental concepts and applications of pattern recognition. [a, k, j]
2. Learn the concepts of Bayes decision theory. [a, e]
3. Understand the concepts of linear and nonlinear classifiers. [a, e]
4. Understand the concepts of feature selection and generation techniques. [a, e]
5. Understand the concepts of supervised learning and system evaluation. [a, e]
6. Understand the concepts of unsupervised learning and clustering algorithms. [a, e]
7. Develop some applications of pattern recognition. [a, b, e, k, j]

Topics Covered:
1. **Bayes decision theory (10 hours)** - Bayes decision theory and discriminant functions and decision surfaces; Estimation of unkown probability density functions; The nearest neighbor rule.
2. **Linear classifiers (10 hours)** - Linear discriminant functions and decision hyperplanes; The perceptron algorithm and least squares methods; Support vector machines.
3. **Nonlinear classifiers (10 hours)** - The two-layer and three layer perceptron and the backpropagation algorithm; Nonlinear support vector machines; Decision trees and combining classifiers.
4. **Feature selection (5 hours)** - Feature selection based on statistical hypothesis tsting; Class separability measures and feature subset selection.

5. **Feature generation (5 hours)** - Fisher's Linear Discriminant and Independent Component Analysis; The singular value decomposition and nonlinear dimensionality reduction.
6. **Template matching (10 hours)** - Measures based on optimal path searching techniques; Measures based on correlations and deformable template models.
7. **Context-dependent classification (5 hours)** - Markov chain models and the Viterbi algorithm; Channel equalization and hidden markov models.
8. **Supervised learning and system evaluation (5 hours)** - Error-counting approach; Exploiting the finite size of the data set.
9. **Unsupervised learning and clustering algorithms (10 hours)** - Introduction of cluster analysis and proximity measures; Categories and clustering algorithms and sequential clustering algorithms;

Class/laboratory schedule:

Timetabled work in hours per week			No of teaching weeks	Total hours	Total credits	No/Duration of exam papers
Lecture	**Tutorial**	**Practice**				
3	Nil	2	14	70	4	1 / 3 hours

Student study effort required:

Class contact:	
Lecture	42 hours
Tutorial	28 hours
Other study effort	
Self-study	42 hours
Homework assignment	9 hours
Project	15 hours
Total student study effort	136 hours

Student assessment:

Final assessment will be determined on the basis of:

- Homework 20%
- Project 30%
- Final Exam 50%

Course assessment:

The assessment of course objectives will be determined on the basis of:

1. Homework, project and exams
2. Course evaluation

Course Outline:

Weeks	Topics	Course work
1,2	**Bayes decision theory** - Bayes decision theory and discriminant functions and decision surfaces	Assignment#1

	- Estimation of unkown probability density functions; - The nearest neighbor rule.	
3,4	**Linear classifiers** - Linear discriminant functions and decision hyperplanes; - The perceptron algorithm and least squares methods; - Support vector machines.	
5,6	**Nonlinear classifiers** - The two-layer and three layer perceptron and the backpropagation algorithm; - Nonlinear support vector machines; - Decision trees and combining classifiers.	Assignment#2
7	**Feature selection** - Feature selection based on statistical hypothesis tsting; - Class separability measures and feature subset selection.	
8	**Feature generation** - Fisher's Linear Discriminant and Independent Component Analysis; - The singular value decomposition and nonlinear dimensionality reduction.	Assignment#3
9,10	**Template matching** - Measures based on optimal path searching techniques; - Measures based on correlations and deformable template models.	Course Project
11	**Context-dependent classification** - Markov chain models and the Viterbi algorithm; - Channel equalization and hidden markov models.	Assignment#4
12	**Supervised learning and system evaluation** - Error-counting approach; - Exploiting the finite size of the data set.	
13,14	**Unsupervised learning and clustering algorithms** - Introduction of cluster analysis and proximity measures; - Categories and clustering algorithms and sequential clustering algorithms;	Assignment#5

Contribution of course to meet the professional component:

This course prepares students to work professionally in the area of pattern recognition.

Relationship to CS program objectives and outcomes:

This course primarily contributes to Computer Science program outcomes that develop student abilities to:
(a) an ability to apply knowledge of mathematics, science, and engineering.
(b) an ability to design and conduct experiments, as well as to analyze and interpret data.
(e) an ability to identify, formulate, and solve engineering problems.
(k) an ability to use the techniques, skills, and modern engineering tools necessary for computer engineering practice.

The course secondarily contributes to Computer Science program outcomes that develop student abilities to:
(j) a knowledge of contemporary issues.

Relationship to CS program criteria:

Criterion	DS	PF	AL	AR	OS	NC	PL	HC	GV	IS	IM	SP	SE	CN
Scale: 1 (highest) to 4 (lowest)								1	2	4	2			

Discrete Structures (DS), Programming Fundamentals (PF), Algorithms and Complexity (AL), Architecture and Organization (AR), Operating Systems (OS), Net-Centric Computing (NC), Programming Languages (PL), Human-Computer Interaction (HC), Graphics

and Visual Computing (GV), Intelligent Systems (IS), Information Management (IM), Social and Professional Issues (SP), Software Engineering (SE), Computational Science (CN).

Course content distribution:

Percentage content for			
Mathematics	Science and engineering subjects	Complementary electives	**Total**
40%	60%	0%	100%

Coordinator:

Chi Man Pun, Associate Professor of Computer Science and Engineering

Persons who prepared this description:

Chi Man Pun, August 23, 2012.

Part B General Course Information and Policies

1st Semester 2012/2013

Instructor: Prof. Chi Man Pun Office: N319
Office Hour: Monday 15:00-16:00, Thursday 15:00-17:00, or by appointment
Phone: 8397-4369
Email: cmpun@umac.mo

Time/Venue:

Lecture	Monday	16:30 - 17:30	WLG104
	Friday	14:30 - 16:30	WLG104
Practice	Saturday	15:30 - 17:30	T103

Grading Distribution:

Percentage Grade	Final Grade	Percentage Grade	Final Grade	Percentage Grade	Final Grade
100 – 93	A	77 – 73	B-	57 – 53	D+
92 – 88	A-	72 – 68	C+	52 – 50	D
87 – 83	B+	67 – 63	C	below 50	F
82 – 78	B	62 – 58	C-		

Comment:
The objectives of the lectures are to explain and to supplement the textbook. Students who wish to succeed in this course should read the correspondence chapters of the textbook prior to the lecture and should work all homework assignments by themselves. You are encouraged to look at other sources (other references, etc.) to complement the lectures and textbook.

Homework Policy:
The completion and correction of homework is a powerful learning experience; therefore:

- There will be approximately 5 homework assignments.
- Homework is due two weeks after assignment unless otherwise noted, no late homework is accepted.
- Possible revision of homework grades may be discussed with the grader within one week from the return of the marked homework
- The course grade will be based on the average of the HW grades.

Course Project:
One course project will be assigned at about the middle of the semester.

Note

- Attendance is strongly recommended.
- Check course web pages for announcement, homework and lectures. Report any mistake on your grades within one week after posting.
- No make-up exam is given except for medical proof.
- Cheating is absolutely prohibited by the university.

Appendix:

Rubric for Program Outcomes

Rubric for (a)	5 (Excellent)	3 (Average)	1 (Poor)
Understand the theoretic background	Students understand theoretic background and the limitations of the respective applications.	Students have some confusion on some background or do not understand theoretic background completely.	Students do not understand the background or do not study at all.
Use a correct model and formulation correctly	Students choose a model correctly and properly apply correct techniques.	Students choose a wrong model sometime, use a wrong formula, or a different technique.	Students use a wrong model and wrong formula, or do not know how to model.
Compute the problem correctly	Students use correct techniques, analyze the problems, and compute them correctly.	Students sometime solve problem mistakenly using wrong techniques.	Students do not know how to solve problems or use wrong techniques completely.

Rubric for (b)	5 (Excellent)	3 (Average)	1 (Poor)
Conduct experiments	Student successfully completes the experiment, records the data, analyzes the experiment's main topics, and explains the experiment concisely and well.	Student successfully completes the experiment, records the data, and analyzes the experiment's main topics.	Student either does not complete the experiment successfully, or completes it successfully but does not record the correct data.
Design experiments	Student understands what needs to be tested and designs an appropriate experiment that takes into account the limitations of the equipment and measurement accuracy.	Student understands what needs to be tested and designs an appropriate experiment, but may not fully understand the limitations of the measurements.	Student does not understand what needs to be tested and/or does not design an appropriate experiment.

Rubric for (e)	5 (Excellent)	3 (Average)	1 (Poor)
Identify applications in engineering	Students understand problem and can identify fundamental formulation.	Students understand problem but cannot apply formulation, or cannot understand problem.	Students cannot identify correct terms for engineering applications.

systems			
Modeling, problem formulation and problem solving	Students choose and properly apply the correct techniques.	Students model correctly but cannot select proper technique or model incorrectly but solve correctly accordingly.	Students at loss as to how to solve a problem.
Rubric for (j)	5 (Excellent)	3 (Average)	1 (Poor)
Relevance to the present time	Student displays an understanding of the theoretical or practical impact and an ability to correlate a subject, perception, communication, association and reasoning from a global and societal perspective.	Student is able to display an understanding of current topics and issues with some knowledge regarding their impact in a bigger global and societal sense.	Student has difficulty demonstrating an awareness or familiarity with current topics and issues relevant to most current global and societal affairs.
Rubric for (k)	5 (Excellent)	3 (Average)	1 (Poor)
Use modern principles, skills, and tools in engineering practice	Student applies the principles, skills and tools to correctly model and analyze engineering problems, and understands the limitations.	Student applies the principles, skills and tools to analyze and implement engineering problems.	Student does not apply principles and tools correctly and/or does not correctly interpret the results.