**University of Macau**
**Computer and Information Science Department**
**CISB451 Fundamentals of Pattern Recognition**
**Syllabus**
**1st Semester 2014/2015**
**Part A – Course Outline**

## Elective course in Computer Science

## Catalog description:

(2-2) 3 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.

## Course type:

Theoretical with substantial laboratory/practice content

## Prerequisites:

CISB122, CISB358

## Textbook(s) and other required material:

- Sergios Theodoridis, *Pattern Recognition*, 4th edition, Elsevier, 2009.
- Richard O. Duda, Peter E. Hart and David G. Stork, *Pattern Classification*, 2nd edition, Wiley Interscience, 2001.

## 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. Understand the fundamental concepts and algorithms of pattern recognition. [a, c]
2. Develop some applications of pattern recognition. [a]

## Topics Covered:

1. **Bayes decision theory (8 hours)** - Bayes decision theory and discriminant functions and decision surfaces; Estimation of unknown probability density functions; The nearest neighbor rule.
2. **Linear classifiers (8 hours)** - Linear discriminant functions and decision hyperplanes; The perceptron algorithm and least squares methods; Support vector machines.
3. **Nonlinear classifiers (8 hours)** - The two-layer and three layer perceptron and the backpropagation algorithm; Nonlinear support vector machines; Decision trees and combining classifiers.
4. **Feature selection (4 hours)** - Feature selection based on statistical hypothesis testing; Class separability measures and feature subset selection.
5. **Feature generation (4 hours)** - Fisher's Linear Discriminant and Independent Component Analysis; The singular value decomposition and nonlinear dimensionality reduction.
6. **Template matching (8 hours)** - Measures based on optimal path searching techniques; Measures based on correlations and deformable template models.
7. **Context-dependent classification (4 hours)** - Markov chain models and the Viterbi algorithm; Channel equalization and hidden markov models.
8. **Supervised learning and system evaluation (4 hours)** - Error-counting approach; Exploiting the finite size of the data set.

9. **Unsupervised learning and clustering algorithms (8 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 | | | | |
| 2 | Nil | 2 | 14 | 56 | 3 | 1 / 3 hours |

## Student study effort required:

| | |
|---|---|
| **Class contact:** | |
| Lecture | 28 hours |
| Tutorial | 28 hours |
| **Other study effort** | |
| Self-study | 42 hours |
| Homework assignment | 9 hours |
| Project | 15 hours |
| **Total student study effort** | 122 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**<br>- Bayes decision theory and discriminant functions and decision surfaces<br>- Estimation of unknown probability density functions;<br>- The nearest neighbor rule. | Assignment#1 |
| 3,4 | **Linear classifiers**<br>- Linear discriminant functions and decision hyperplanes;<br>- The perceptron algorithm and least squares methods;<br>- Support vector machines. | |
| 5,6 | **Nonlinear classifiers**<br>- The two-layer and three layer perceptron and the backpropagation algorithm;<br>- Nonlinear support vector machines;<br>- Decision trees and combining classifiers. | Assignment#2 |
| 7 | **Feature selection**<br>- Feature selection based on statistical hypothesis testing;<br>- Class separability measures and feature subset selection. | |

| | | |
|---|---|---|
| 8 | **Feature generation**<br>- Fisher's Linear Discriminant and Independent Component Analysis;<br>- The singular value decomposition and nonlinear dimensionality reduction. | Assignment#3 |
| 9,10 | **Template matching**<br>- Measures based on optimal path searching techniques;<br>- Measures based on correlations and deformable template models. | Course Project |
| 11 | **Context-dependent classification**<br>- Markov chain models and the Viterbi algorithm;<br>- Channel equalization and hidden markov models. | Assignment#4 |
| 12 | **Supervised learning and system evaluation**<br>- Error-counting approach;<br>- Exploiting the finite size of the data set. | |
| 13,14 | **Unsupervised learning and clustering algorithms**<br>- Introduction of cluster analysis and proximity measures;<br>- Categories and clustering algorithms and sequential clustering algorithms; | Assignment#5 |

## Student Disabilities Support Service:

The University of Macau is committed to providing an equal opportunity in education to persons with disabilities. If you are a student with a physical, visual, hearing, speech, learning or psychological impairment(s) which substantially limit your learning and/or activities of daily living, you are encouraged to communicate with your instructors about your impairment(s) and the accommodations you need in your studies. You are also encouraged to contact the Student Disability Support Service of the Student Counselling and Development Section (SCD), which provides appropriate resources and accommodations to allow each student with a disability to have an equal opportunity in education, university life activities and services at the University of Macau. To learn more about the service, please contact SCD at scd.disability@umac.mo, or 8397 4901 or visit the following website:
http://www.umac.mo/sao/scd/sds/aboutus/en/scd_mission.php

## Coordinator:

Chi Man Pun, Associate Professor of Computer Science and Engineering

## Persons who prepared this description:

Chi Man Pun, July 8, 2015

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## Part B General Course Information and Policies

### 1st Semester 2014/2015

Instructor: Prof. Chi Man Pun  Office: E11-4090
Office Hour: Monday 10:00 - 12:00, 15:00-17:00, Friday 15:00-16:00, or by appointment
Phone: 8822-4369
Email: cmpun@umac.mo

**Time/Venue:**

| | | | |
|---|---|---|---|
| ***Lecture*** | Wednesday | 08:30 -11:30 | HG01 |
| ***Practice*** | Friday | 13:30 -15:30 | NG02 |

**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:**

***<u>Measurement Dimensions and Rubric for Programme Outcomes (a) to (j)</u>***

*(a) An ability to apply knowledge of computing and mathematics to solve complex computing problems in computer science discipline.*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
| --- | --- | --- | --- |
| **1. An ability to apply knowledge of computing to the solution of complex computing problems.** | Students understand the computing principles, and their limitations in the respective applications. Use the computing principles to formulate and solve complex computing problems. | Students understand the computing principles, and their limitations in the respective applications. But they have trouble in applying these computing principles to formulate and solve complex computing problems. | Students do not understand the computing principles, and their limitations in the respective applications. Do not know how to apply the appropriate computing principles to formulate and solve complex computing problems. |
| 2. **An ability to apply knowledge of mathematics to the solution of complex computing problems.** | Students understand the mathematical principles, e.g., calculus, linear algebra, probability and statistics, relevant to computer science, and their limitations in the respective applications. Use mathematical principles to formulate and solve complex computing problems. | Students understand the theoretical background and know how to choose mathematical principles relevant to computer science. But they have trouble in applying these mathematical principles to formulate and solve complex computing problems. | Students do not understand the mathematical principles and do not know how to formulate and solve complex computing problems. |

*(b) An ability to apply knowledge of a computing specialisation, and domain knowledge appropriate for the computing specialisation to the abstraction and conceptualisation of computing models*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
| --- | --- | --- | --- |
| **1. An ability to apply knowledge of a computing specialisation, and domain knowledge to analyse and abstract complex computing models** | Students understand the computing specialisation, and domain knowledge. They can also analyze and abstract complex computing models. | Students understand the computing specialisation, and domain knowledge. But they have trouble in analyzing and abstracting complex computing models. | Students have trouble in understanding the computing specialisation, and domain knowledge, and do not know how to analyze and abstract complex computing models. |
| **2. An ability to apply knowledge of a computing specialisation, and domain knowledge to conceptualize complex computing models** | Students understand the computing specialisation, and domain knowledge. They can also conceptualize complex computing models. | Students understand the computing specialisation, and domain knowledge. But they have trouble in conceptualizing complex computing models. | Students have trouble in understanding the computing specialisation, and domain knowledge, and do not know how to conceptualize complex computing models. |

*(c) An ability to analyse a problem, and identify and define the computing requirements appropriate to its solution*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to understand problem and identify the fundamental formulation** | Students understand problem correctly and can identify the fundamental formulation | Student understand problem correctly, but have trouble in identifying the fundamental formulation | Students cannot understand problem correctly, and they do not know how to identify the fundamental formulation |
| **2. An ability to choose and properly apply the correct techniques** | Students know how to choose and properly apply the correct techniques to solve problems. | Students can choose correct techniques but have trouble in applying these techniques to solve problems. | Students have trouble in choosing the correct techniques to solve problems. |

*(d) An ability to design, implement, and evaluate a computer-based system, process, component, or program to meet desired needs with appropriate consideration for public health and safety, social and environmental considerations*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to design, implement, and evaluate a computer-based system, process, component, or program** | Students understand how to properly design, implement and evaluate a computer-based system, process, component, or program | Students understand how to design and implement a computer-based system, process, component, or program, but have trouble in evaluating it. | Students do not know how to design, implement, and evaluate a computer-based system, process, component, or program |
| **2. An ability to understand what needs to be designed and the realistic design constraints regarding public health and safety, social and environmental considerations.** | Students understand the design goals and the realistic design constraints regarding public health and safety, social and environmental considerations. | Students understand the design goals; but they are not clear about the realistic design constraints regarding public health and safety, social and environmental considerations. | Students have trouble in understanding what needs to be designed and the realistic design constraints regarding public health and safety, social and environmental considerations. |

*(e) An ability to function effectively on teams to accomplish a common goal*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to accomplish the assigned tasks** | Students understand the assigned tasks well, and can accomplish the tasks to meet all the requirements. | Students understand the assigned tasks well, but have difficulties in fully accomplishing the tasks. | Students have trouble in understand the assigned tasks, and cannot accomplish them. |
| **2. An ability to work with the other team members in an effective manner.** | Students can effectively communicate with the other team members, and can work together to accomplish a common goal. | Students can effectively communicate with the other team members, but have trouble in working effectively to accomplish a | Students cannot effectively communicate with the other team members, and cannot work together to accomplish a common |

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|---|---|---|---|
| | | common goal. | goal. |

*(f) An understanding of professional, ethical, legal, security and social issues and responsibilities*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to understand how to critique and analyse design trade-offs and constraints with respect to liability and integrity of data, and context of use.** | Students understand the design trade-offs and constraints with respect to liability and integrity of data, and context of use. They also know how to appropriately critique and analyze these tradeoffs. | Students understand the design trade-offs and constraints with respect to liability and integrity of data, and context of use. But they have trouble in appropriately critiquing and analyzing these tradeoffs. | Students cannot understand the design trade-offs and constraints with respect to liability and integrity of data, and context of use. They do not know how to critique and analyze these tradeoffs. |
| **2. An ability to understand how to critique and analyse design trade-offs and constraints with respect to research issues of credit and authorship, integrity of data, and informed consent.** | Students understand the design trade-offs and constraints with respect to research issues of credit and authorship, integrity of data, and informed consent. They also know how to appropriately critique and analyze these tradeoffs. | Students understand the design trade-offs and constraints with respect to research issues of credit and authorship, integrity of data, and informed consent. But they have trouble in appropriately critiquing and analyzing these tradeoffs. | Students cannot understand the design trade-offs and constraints with respect to research issues of credit and authorship, integrity of data, and informed consent. They do not know how to critique and analyze these tradeoffs. |
| **3. An ability to understand how to critique and analyse design trade-offs and constraints with respect to conflict of interest, bribery, professional dissent, authorship, discrimination, and codes of ethics** | Students understand the design trade-offs and constraints with respect to conflict of interest, bribery, professional dissent, authorship, discrimination, and codes of ethics. They also know how to appropriately critique and analyze these tradeoffs. | Students understand the design trade-offs and constraints with respect to conflict of interest, bribery, professional dissent, authorship, discrimination, and codes of ethics. But they have trouble in appropriately critiquing and analyzing these tradeoffs. | Students cannot understand the design trade-offs and constraints with respect to conflict of interest, bribery, professional dissent, authorship, discrimination, and codes of ethics. They do not know how to critique and analyze these tradeoffs. |

*(g) An ability to communicate effectively with a range of audiences*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to comprehend and write effective reports and clear design documents on complex computing activities.** | Students produce well-organized reports and documents on complex computing activities, with adequate content and understandable language, grammar or syntax. | Students produce reports and documents on complex computing activities, with adequate content and language, grammar or syntax with some errors. | Students produce reports and documents with inadequate content, barely understandable language, grammar or syntax. |
| **2. An ability to make effective presentations on complex computing activities to the computing community and the society at large.** | Students make effective oral presentations and rational responses. | Students make oral presentations but cannot give rational responses. | Students are unable to make oral presentations and responses. |

*(h) An ability to analyse the local and global impact of computing on individuals, organisations, and society*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to analyse the local and global impact of computing on individuals and society** | Students understand the local and global impact of computing on individuals and society, and can analyze such impact in terms of scope and depth. | Students understand the local and global impact of computing on individuals and society, but have trouble in analyzing such impact in terms of scope and depth. | Students cannot understand the local and global impact of computing on individuals and society |
| **2. An ability to analyse the local and global impact of computing on organizations.** | Students understand the local and global impact of computing on organizations, and can analyze such impact in terms of scope and depth. | Students understand the local and global impact of computing on organizations, but have trouble in analyzing such impact in terms of scope and depth. | Students cannot understand the local and global impact of computing on organizations |

*(i) Recognition of the need for and an ability to engage in continuing professional development*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to recognize the need for continuing professional development** | Students understand the professional development, and recognize the need for continuing professional development | Students understand the professional development, but have trouble in recognizing the need for continuing professional development | Students cannot understand the professional development, and cannot recognize the need for continuing professional development |
| **2. An ability to engage in continuing professional development** | Students actively engage in continuing professional development, and achieve satisfactory. | Students engage in continuing professional development, but the performance achieved is not satisfactory. | Students do not engage in continuing professional development. |

*(j) An ability to use current techniques, skills, and tools necessary for computing practice with an understanding of the limitations.*

| Measurement Dimension | Excellent (80-100%) | Average (60-79%) | Poor (<60%) |
|---|---|---|---|
| **1. An ability to use computer/IT skills and tools relevant to computing practice, and understands their limitations.** | Students can correctly identify the computer/IT skills and tools relevant to computing practice, and understand their limitations. They can also apply these tools to solve practical computing problems. | Students can correctly identify the computer/IT skills and tools relevant to computing practice, and understand their limitations. But they have trouble in applying these tools to solve practical computing problems. | Students cannot correctly identify the computer/IT skills and tools relevant to computing practice, and understand their limitations. They have trouble in applying the appropriate tools to solve practical computing problems. |
| **2. An ability to use the computing principles to model and analyse computing problems,** | Students understand the computing principles relevant to computing problems. They can also use | Students understand the computing principles relevant to computing problems. But they have | Students have trouble in understanding computing principles relevant to computing problems. They |

| | | | |
|---|---|---|---|
| **and understands the limitations.** | these principles to model and analyse computing problems, and understand the limitations. | trouble in applying these principles, skills and tools to model and analyse computing problems, and understand the limitations. | do not know how to apply these principles, skills and tools to model and analyse computing problems, and understand the limitations. |