University of Macau
Faculty of Science and Technology
Department of Computer and Information Science
CISB450 Advanced Artificial Intelligence
Syllabus
1st Semester 2014/2015
Part A – Course Outline

Elective course in Computer Science

Course description:
(2-2) 3 credits. This course introduces key concepts of artificial intelligence and application areas. Topics include expert systems, computational intelligence, machine learning, genetic algorithms, and clustering. Upon completion of this course, students should be able to apply various artificial intelligence techniques in developing intelligent systems.

Course Type:
Theoretical with substantial laboratory/practice content

Prerequisites:
- CISB 385 Fundamental Artificial Intelligence

Textbook(s) and other required material:
- Michael Negnevitsky, *Artificial Intelligence: A Guide to Intelligent Systems*, Addison Wesley; 2nd edition, 27 Sep 2004. ISBN-10: 0321204662, ISBN-13: 978-0321204660

References:
- Stuart Russell, Peter Norvig, *Artificial Intelligence: A Modern Approach*, Prentice Hall; 2 edition, December 11, 2009.
- Tom Mitchell, *Machine Learning*, McGraw Hill, 1997.
- Elaine Rich, Kevin Knight, *Artificial Intelligence*, McGraw-Hill Science/Engineering/Math; 2nd edition, December 1, 1990.
- Fakhreddine O. Karray and Clarance De Silva, *Soft computing and Intelligent systems Design, Theory and Applications*, Addison Wesley, Academic Press; 1st edition, October 15, 1999.
- Mitchell Melanie, *An Introduction to Genetic Algorithms*, Cambridge, Mass., MIT Press, 1998.

Major prerequisites by topic:
- Basic concepts in discrete structures, probability, calculus, and linear algebra.
- Intermediate programming.

Course objectives:
- Introduce to students the major topics of artificial intelligence and application areas. [a]
- Introduce students to the methods and algorithms for developing intelligent systems. [a]
- Introduce students to the design and implementation of intelligent systems. [a, c]

Topics covered:
- **Introduction to Intelligent Systems (3 hours)**: Definition of Intelligence. Review the history of artificial intelligence (from 1943 – current).
- **Rule-based Expert Systems (3 hours)**: Discuss what is knowledge is and how experts express their knowledge in the form of production rules. Identify the main players in the expert system development team and structure of a rule-based expert system. Review forward chaining and backward chaining, conflict Resolution, advantages and disadvantages of rule-based expert system. A brief introduction to CLIPS expert system shell.
- **Reasoning under Uncertainty (3 hours)**: Review the probability theory. Present two uncertainty management techniques used in expert systems: Bayesian reasoning and certainty factors. Study Naïve Bayes Classification.
- **Fuzzy Expert Systems (3 hours)**: Introduce fuzzy logic and discuss the philosophical ideas behind it. Review fuzzy sets, linguistic variables, hedges, fuzz rules. Explore two fuzzy inference techniques: Mamdani-style

inference, Sugeno-style inference. Introduce the main steps in developing a fuzzy expert system and illustrate the theory through the actual process of building and tuning a fuzzy system using MATHLAB fuzzy logic toolbox.

- **Artificial Neural Networks (6 hours)**: Discuss the basic idea behind machine learning. Present the concept of perceptron as a simple computing element and consider the perceptron learning rule. Discuss the concept of multilayer neural networks (Back-propagation algorithm), and study the accelerated learning in multilayer neural networks. Review recurrent neural networks (Hopfield network and bidirectional associated memory). Review self-organizing neural networks (Hebbian learning and Kohonen network).
- **Evolutionary Computation (6 hours)**: Present the overview of evolutionary computation. Introduce the main steps in developing a genetic algorithm. Introduce the schema theorem. Study evolution strategies and genetic programming.
- **Hybrid Intelligent Systems (6 hours)**: Consider the hybrid intelligent system as a combination of different intelligent technologies. Study neural expert systems, neuro-fuzzy systems, evolutionary neural networks, fuzzy evolutionary systems.
- **Concept Learning, Decision Tree Learning (6 hours)**: Study Find-S algorithm, list-than-eliminate algorithm, candidate-elimination algorithm. Discuss the ID3 algorithm for decision tree learning.
- **Instance-based Learning (3 hours)**: Study the advantages and disadvantages of instance-based learning. Discuss K-nearest neighbor algorithms for approximating a discrete-valued and continuous-valued function. Study distance-weighted nearest neighbor algorithms for discrete-valued and continuous-valued target functions. Review the architecture of a case-based reasoning system.
- **Clustering (3 hours)**: Unsupervised learning and clustering, K-means algorithm

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	2	Nil	14	56	3	2 / 2+2 hours

Student study effort required:

Class contact:	
Lecture	28 hours
Tutorial	28 hours
Other study effort	
Self-study	28 hours
Homework assignment	10 hours
Project assignments	20 hours
Total student study effort	114 hours

Student assessment:

Final assessment will be determined on the basis of:

Homework	15%	Course Project	25%
Mid-term	30%	Final exam	30%

Course assessment:

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

- Assignments (written, programming) and exams
- Course evaluation

Course outline:

Weeks	**Topic**	**Course work**
1	**Introduction to Knowledge-based Intelligent Systems**	Assignment#1

Weeks	Topic	Course work
	Definition of intelligence, Turing imitation game, the birth of artificial intelligence (1943-56), the rise of artificial intelligence (1956-late 1960), the impact of reality (late 1960 – early 1970), the technology of expert systems (early 1970 – mid 1980), how to make the machine learn (mid 1980 – onwards), evolutionary computation (1970 – onwards), the new era of knowledge engineering (late 1980 – onwards).	
2-3	**Evolutionary Computation** Genetic algorithms, Schema Theorem, evolution strategies, genetic programming	Course Project
4	**Rule-based Expert Systems** Knowledge representation technique, the main players in the expert system development team, structure of a rule-based expert system, forward chaining and backward chaining, conflict Resolution, advantages and disadvantages of rule-based expert system, CLIPS expert system shell.	Assignment#2
5	**Reasoning Under Uncertainty** Bayesian reasoning, Certainty factors theory and evidential reasoning, comparison of Bayesian reasoning and certainty factors, Naïve Bayes Classification	
6	**Fuzzy Expert Systems** Fuzzy sets, linguistic variables, hedges, fuzz rules, Mamdani-style inference, Sugeno-style inference, MATHLAB fuzzy logic toolbox	Assignment#3
7-8	**Artificial Neural Networks** How the brain works, the neuron, the perceptron, multilayer neural networks (Back-propagation algorithm), accelerated learning in multilayer neural networks, the Hopfield network, bidirectional associated memory, Self-organizing neural network (Hebbian learning and Kohonen network)	Assignment#4 Midterm
9-10	**Hybrid Intelligent Systems** Neural expert systems, neuro-fuzzy systems, evolutionary neural networks, fuzzy evolutionary systems	Assignment#5
11-12	**Concept Learning, Decision Tree Learning** Find-S algorithm, list-than-eliminate algorithm, candidate-elimination algorithm, ID3 algorithm	Assignment#6
13	**Instance-based Learning** K-nearest neighbor algorithm for approximating a discrete-valued and continuous-valued function, distance-weighted nearest neighbor algorithm for discrete-valued and continuous-valued target functions, case-based reasoning	
14	**Clustering** Unsupervised learning and clustering, K-means algorithm	

Contribution of course to meet the professional component:
This course prepares students to work professionally in the area of Artificial Intelligence.

Relationship to CS program objectives and outcomes:
This course primarily contributes to the Computer Science program outcomes that develop student abilities to:
(a) An ability to apply knowledge of computing and mathematics appropriate to the programme outcomes and to the discipline.
(c) An ability to analyse a problem, and identify and define the computing requirements appropriate to its solution.

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)							4			1				

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**
10%	40%	50%	100%

Coordinator:
Prof. Chi Man Pun

Persons who prepared this description:
Dr. Yain Whar Si
Dr. Long Chen, Aug 10, 2014 (Revised)

Part B – General Course Information and Policies

1st Semester 2014/2015

Instructor: Dr. Long Chen Office: E11-4014
Office hour: by appointment Phone: 8822 8459
Email: longchen@umac.mo

Time/Venue: Thursday 16:00-17:45 E6-2092(LA)
Tuesday 16:00-17:45 E11-1026(L)

Grading distribution:

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

Comment:
The objectives of the lectures are to explain and to supplement the text material. Students are responsible for the assigned material whether or not it is covered in the lecture. Students are encouraged to look at other sources (other references, etc.) to complement the lectures and text.

Homework policy:
The completion and correction of homework is a powerful learning experience; therefore:
- There will be approximately 7 homework assignments.
- Homework is basically due one week after assignment unless otherwise noted.
- Some homework assignments may pop up in the class as quizzes.

Quizzes:
One mid-term exam will be held during the semester.

Note:
- Check UMMoodle (UMMoodle.umac.mo) for announcement, homework and lectures. Report any mistake on your grades within one week after posting.
- No make-up exam is given except for CLEAR medical proof.
- Cheating is absolutely prohibited by the university.

Appendix:

Rubric for Program Outcomes

(a) An ability to apply knowledge of computing and mathematics appropriate to the programme outcomes and to the 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.

(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 problem.	Students can choose correct techniques but have trouble in applying these techniques to solve problem.	Students have trouble in choosing the correct techniques to solve problem.

學生身心障礙支援服務

學生身心障礙支援服務澳門大學致力為身心障礙人士提供平等的學習機會，若您在肢體、視力、聽力、語言、學習或心理上的障礙，導致您在學習或日常活動中受到嚴重的限制，我們鼓勵您與老師溝通，讓他/她知道你的狀況，並作出適當的安排。此外，我們也鼓勵您與學生輔導及發展處之學生身心障礙支援服務聯繫，該服務將為有需要的學生提供相應的資源和設施，讓所有學生都能在大學裏享有同等的教育機會、大學生活及服務。如閣下對此服務有任何疑問，歡迎聯絡學生事務部---學生輔導及發展處（電郵：scd.disability@umac.mo；電話：88224901；瀏覽網頁 http://www.umac.mo/sao/scd/sds/aboutus/cn/scd_mission.php）。

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) in Student Affairs Office, 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 8822 4901 or visit the following website: http://www.umac.mo/sao/scd/sds/aboutus/en/scd_mission.php.

Serviço de Apoio aos Estudantes Portadores de Deficiência

A Universidade de Macau (UM) compromete-se a oferecer oportunidades iguais de educação para as pessoas portadoras de deficiência. Caso o aluno tenha deficiência física, visual, auditiva, mental, ou dificuldades de fala ou de aprendizagem, que afectem consideravelmente a sua aprendizagem ou actividades quotidianas, convém comunicar estas dificuldades aos professores para pedir apoio necessário. É também aconselhável contactar o Serviço de Apoio à Deficiência dos Alunos da Secção para Aconselhamento e Desenvolvimento dos Estudantes (SADE), à qual compete oferecer recursos e condições para que os alunos portadores de deficiência tenham oportunidades iguais na educação, actividades e serviços universitários na UM. Para mais informações sobre este serviço, é favor contactar a SADE via email: scd.disability@umac.mo, telefone 8822 4901 ou visitar a página electrónica http://www.umac.mo/sao/scd/sds/aboutus/en/scd_mission.php.