UNIVERSITY OF MACAU
DEPARTMENT OF COMPUTER AND INFORMATION SCIENCE
SFTW 463 – Data Visualization
Syllabus
1st Semester 2011/2012
Part A – Course Outline

Elective required course in Computer Science

Catalog description:
(2-2) 3 credits. Scientific visualization and information visualization; data visualization pipeline from data filtering, data mapping and rendering; data types and data representation; scalar, vector and tensor data; volume visualization and surface visualization; visualization software.

Course type:
Theoretical with substantial laboratory/practice content

Prerequisites:
- MATH 101, MATH102; SFTW111, SFTW210

Textbook(s) and other required material:
- Alexandru C. Telea, ***Data Visualization – Principles & Practice***, A K Peters, 2008.

References:
- Klaus Engel, Markus Hadwiger, Joe Kniss, Christof Rezk-Salama, Daniel Weiskopf, ***Real-Time Volume Graphics,*** A K Peters, 2006.
- Barthold Lichtenbelt, Randy Crane, Shaz Naqvi, ***Introduction to Volume Rendering***, Prentice Hall, 1998.
- Donald Hearn and M. Pauline Baker, ***Computer Graphics with OpenGL,*** 3rd Edition, Pearson Prentice Hall, 2004.

Major prerequisites by topic:
1. Fundamental calculus.
2. Continuous and discrete mathematics.

Course objectives:
1. Introduce the basic concepts in data visualization [k, e]
2. Learn the basic techniques to produce visualization entities [a, k]
3. Understand the data visualization pipeline and methods to create the visualization images [a, e]
4. Learn visualization models and various data visualization techniques [a,b,c]
5. Apply the techniques by using data visualization software and/or programming [b,k,e]

Topics covered:

1. **Basic concept & visualization pipeline (3 hours).** Introduce the fundamental concept of data visualization, from various views for making investigation of visualizing data. Introduce the data visualization procedure by a detail description of the visualization pipeline. Various stages in the pipeline are explained, and user interaction at each stage is also introduced. The introduction will be also given with various applications as examples.
2. **Principle of graphics rendering (3 hours).** Graphics generation is a key tool in the data visualization, so a review on the graphics modeling and rendering will be made. The primary graphics primitives and the rendering procedure are introduced, basically following the principle of OpenGL graphics user interface.
3. **Data types and data representation (2 hours).** Review the concept of continuous and discrete data. Introduce various data types and their representations. Introduce various grids and cells, particularly to those commonly used in the visualization applications.
4. **Scalar visualization (5 hours).** Introduce typical visualization techniques to scalar data; color mapping technique and effective color map design; contouring technology and Marching-Cubes algorithm; height plots.
5. **Vector visualization (5 hours).** Introduce the definition of vector data and the main feature of vector data fields as well as the computation algorithms for the feature like divergence and vorticity. Discuss a number of popular visualization methods for vector data sets like vector glyphs, vector color coding, displacement plots, stream object methods, texture-based vector visualization. Analyze the methods by their features and suitability to various applications.
6. **Volume visualization (5 hours).** Introduce the fundamentals of volume data and volume visualization, the concept of transfer function and classification in the volume visualization procedure. Study the optical model and the ray function / compositing function, with its mathematical expression and the discrete format introduced. Introduce the image-order and object-order methods in the volume visualization.
7. **Information visualization (3 hours).** Introduce the concept of information data and information visualization, in comparison with the data format in scientific visualization. Discuss various typical methods applied in information visualization.

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	3.0	1 / 3 hours

Student study effort required:

Class contact:	
Lecture	28 hours
Tutorial	24 hours
In-class assignment / Hands-on practice	4 hours
Other study effort	
Self-study	32 hours
Homework assignment	12 hours
Total student study effort	100 hours

Student assessment:

Final assessment will be determined on the basis of:

Homework 20%

Mid-term 30% Final Exam 50%

Course assessment:

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

1. Homework and exams
2. Course evaluation

Course outline:

Weeks	Topic	Course work
1	**Introduction** Definition of data visualization(DV), various applications of DV, significance and history of DV, categories of DV, DV pipeline, processing procedure of DV	
2	**From Graphics to Visualization** Fundamental of graphics, light sources, surface lighting effects, illumination models, rendering methods	
3	**Data Representation** Continuous/Discrete Data, Discrete Datasets, Cell Types, Grid Types	Assignment#1
4	**Visualization Pipeline** Detail of visualization pipeline, implementation considerations, algorithms used in the visualization, structure of the visualization applications	
5,6	**Scalar Data Visualization** Visualization of scalar data, color mapping and design of color maps, contouring in 2D and 3D, Marching-cube algorithm, height plots	Assignment#2
7,8	**Vector Data Visualization** Divergence and vorticity of vector fields, vector glyphs & color coding, displacements plots, stream objects	Assignment#3
9	**Mid-term review and mid-term exam.**	Mid-term exam
10,11	**Volume Visualization** Fundamentals of volume visualization, image-order techniques, object-order techniques, volume rendering vs. geometric rendering	Assignment#4
12,13	**Information Visualization** Scientific visualization vs. information visualization, data features of Information visualization, various methods on Infovis	
14	**Review and Final Examination**	Final Exam

Contribution of course to meet the professional component:

This course provides students the fundamental knowledge of data visualization required for their professional career in this field.

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.

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The course secondarily contributes to Computer Science program outcomes that develop student abilities to:

(b) an ability to design and conduct experiments, as well as to analyze and interpret data

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

(e) an ability to identify, formulate, and solve engineering problems.

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)			3					3	1				4	3

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%	90%	0%	100%

Coordinator:

Prof. Chi-Man Pun

Persons who prepared this description:

Prof. Enhua Wu, Dr. Wen Wu

Part B General Course Information and Policies

1st Semester 2011/2012

Instructor: Prof. Dr. Enhua WU
Office Hour: by appointment
Email: ehwu@umac.mo

Office: N503
Phone: 8397-4953

Time/Venue: **(***to be announced*);

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:

This course is to provide students with a comprehensive introduction to data visualization techniques. These techniques are taught in theoretical and technical learning. At the same time the students are learning the algorithms and methods, they have to make practice to learn how to visualize various kinds of data types, by using available software tools and/or programming.

Homework Policy:

The review and homework practice is an essential way to grasp the principle of the course.

- There will be approximately 4-5 homework assignments.
- Homework is due one week after assignment unless otherwise noted, generally no late homework is accepted.
- The homework should be completed independently.

Quiz

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

Note

- Reading the textbook is imperative, and attendance is strongly recommended.
- Check UMMoodle (https://ummoodle.umac.mo/) for lecture notes, homework and resources etc.
- Cheating is absolutely prohibited by the university. Issues regarding the final exam follow the university rules and policies.

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.

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.

Rubric for (c)	5 (Excellent)	3 (Average)	1 (Poor)
Design capability and design constraints	Student understands very clearly what needs to be designed and the realistic design constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Student understands what needs to be designed and the design constraints, but may not fully understand the limitations of the design constraints.	Student does not understand what needs to be designed and the design constraints.

Rubric for (e)	5 (Excellent)	3 (Average)	1 (Poor)
Identify applications in engineering systems	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.

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.