Topics in Computer Graphics

Goals of Computer Graphics

- To use computer and mathematical techniques to build a virtual, real-like 3D world, animated by time changes, inside the computer
- To study techniques that can render the virtual 3D world to real-like 2D images and movies

Movie Industry Applications

Different kinds of “CG” movies

- Type I: Created entirely Using CG

  e.g. ”Fozen 2”

- Type 2: Real people + CG characters

  e.g. “District 9”

- Type 3: CG Movie + Real People

  e.g. “Space Battleship Yamato”

- Type 4: Conventional movie with CG special effects

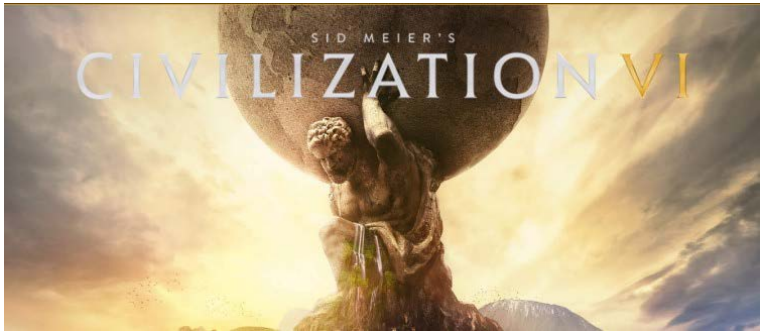
  e.g. “Initial D” (production documentary)

- Type 5: “3D Movies”

  e.g. “Avatar”

Game Industry Applications

- Mobile phone games (i-phone apps, android …)
- Playstation (PS, Nintendo, Sega …)
- PC Single Person games (Single player and multiple player)
- Hand held games
- Web games
- Motion control games
- …



Advertising Industry Applications

- Commercials in TV

  e.g. TVB Jade
- animations in web page

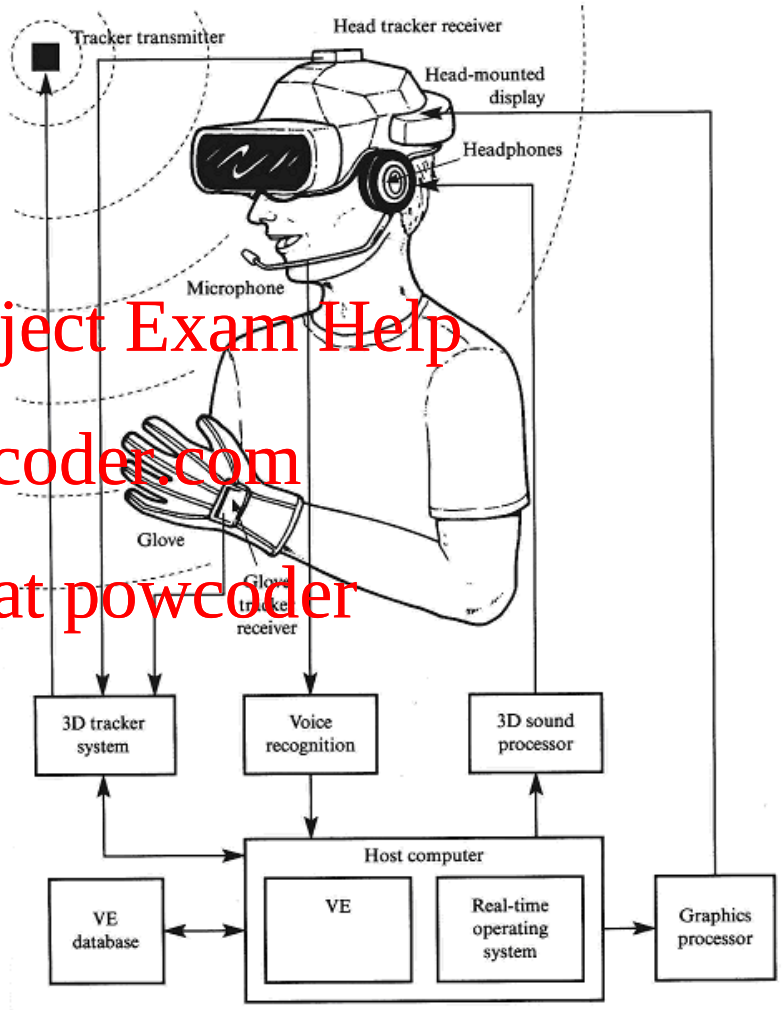
  e.g. South China Morning Post

Design Industry Applications

- Computer Aided Design (CAD)

Virtual Reality Industry Application

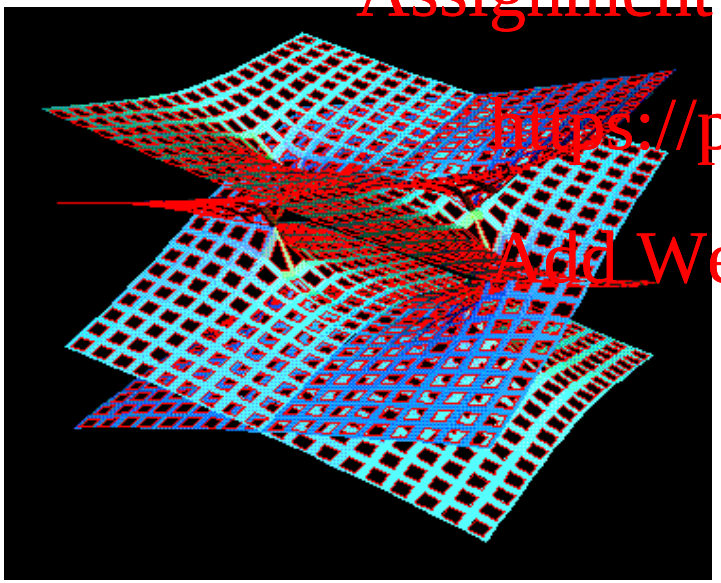
- VR creates an immersive environment such that the user has the false but real sensation of being in an artificially created world
- Applications in games, medical therapy, visualization, design, surgery practice, teaching, …



Other less well known Applications

- Visualization

  Visualize mathematical problems

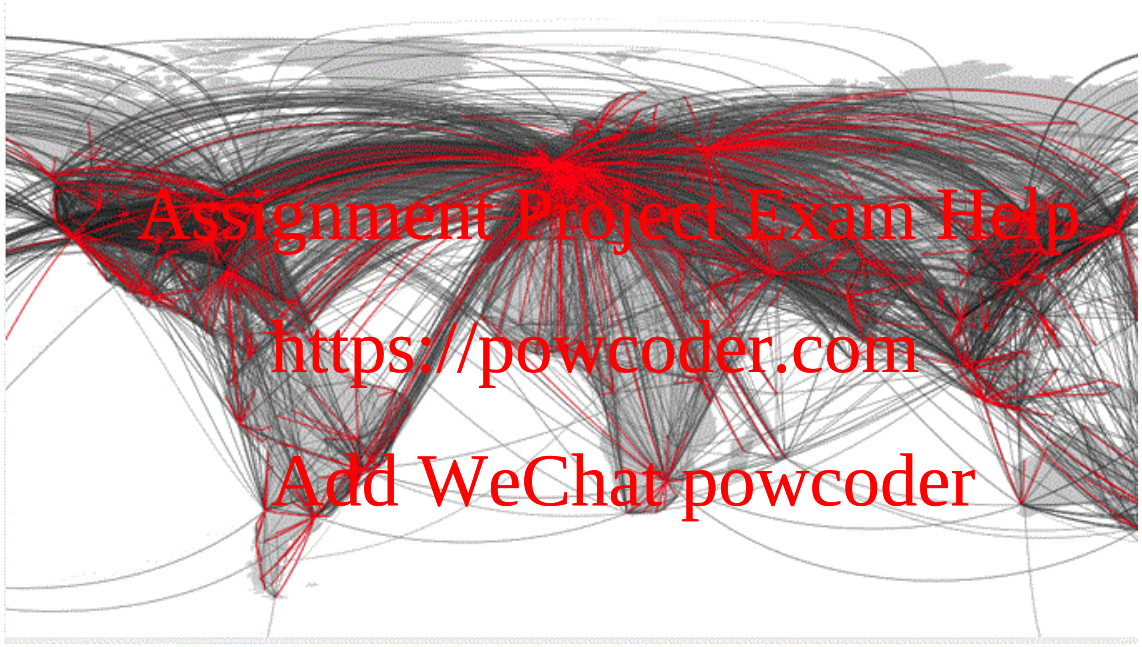


Riemann Hypothesis

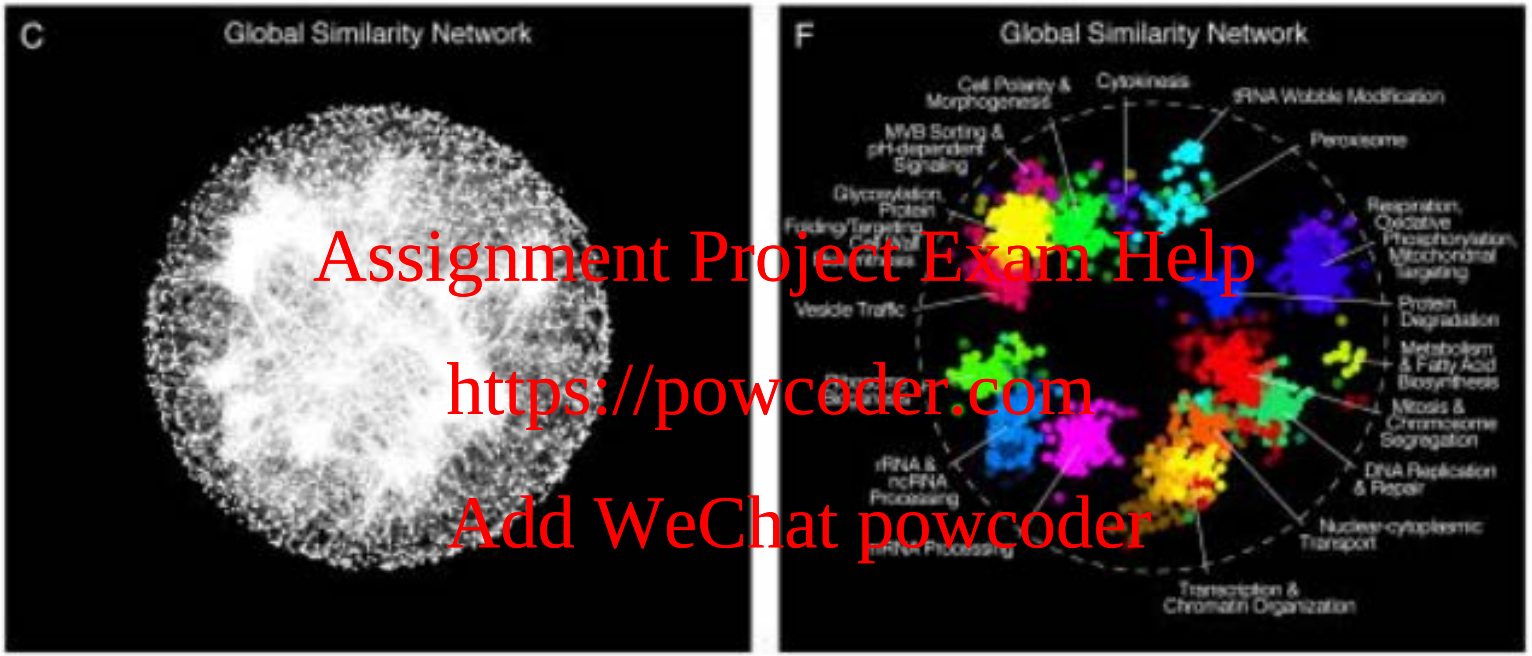
UNCRACKABLE? The Collatz Conjecture

Goldbach's Conjecture

Complex networks



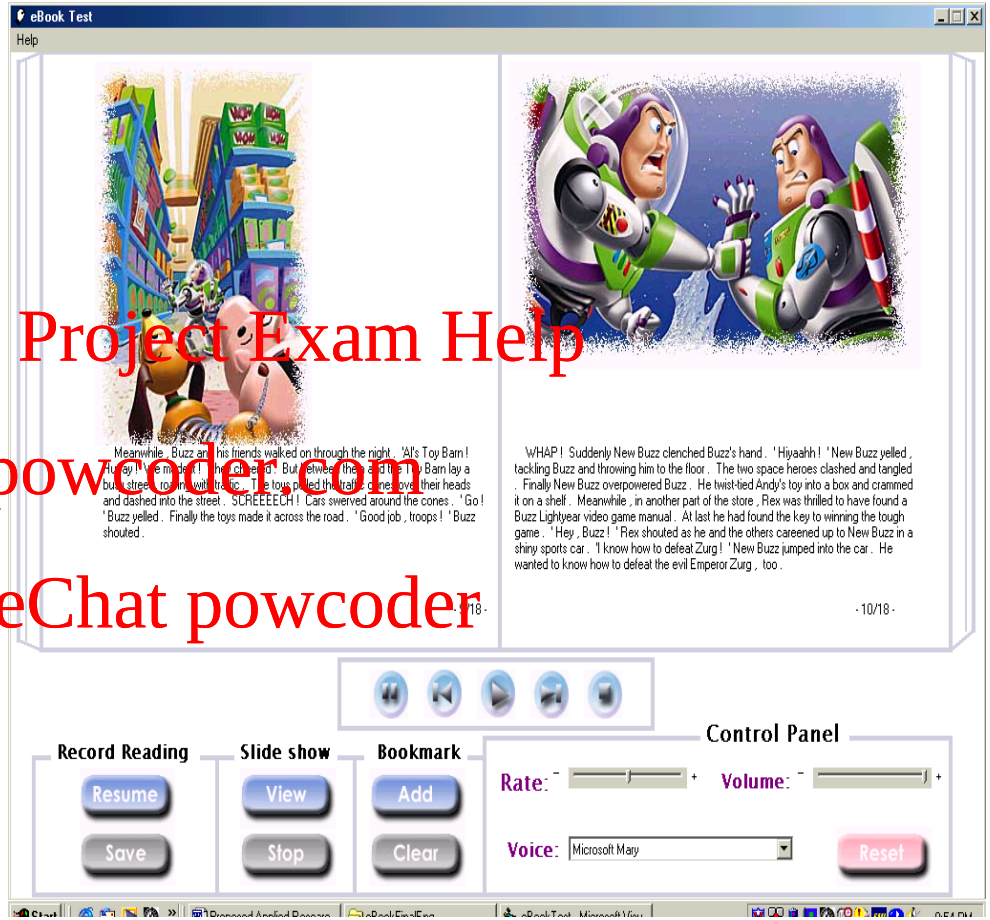
Worldwide air transportation network



A global genetic interaction network maps a wiring diagram of cellular function

- Training
  - flight simulator
  - car simulator
  - spaceship cabin simulator
  - …

- Education
  - animated story book
  - animated presentation



Electronic books for children

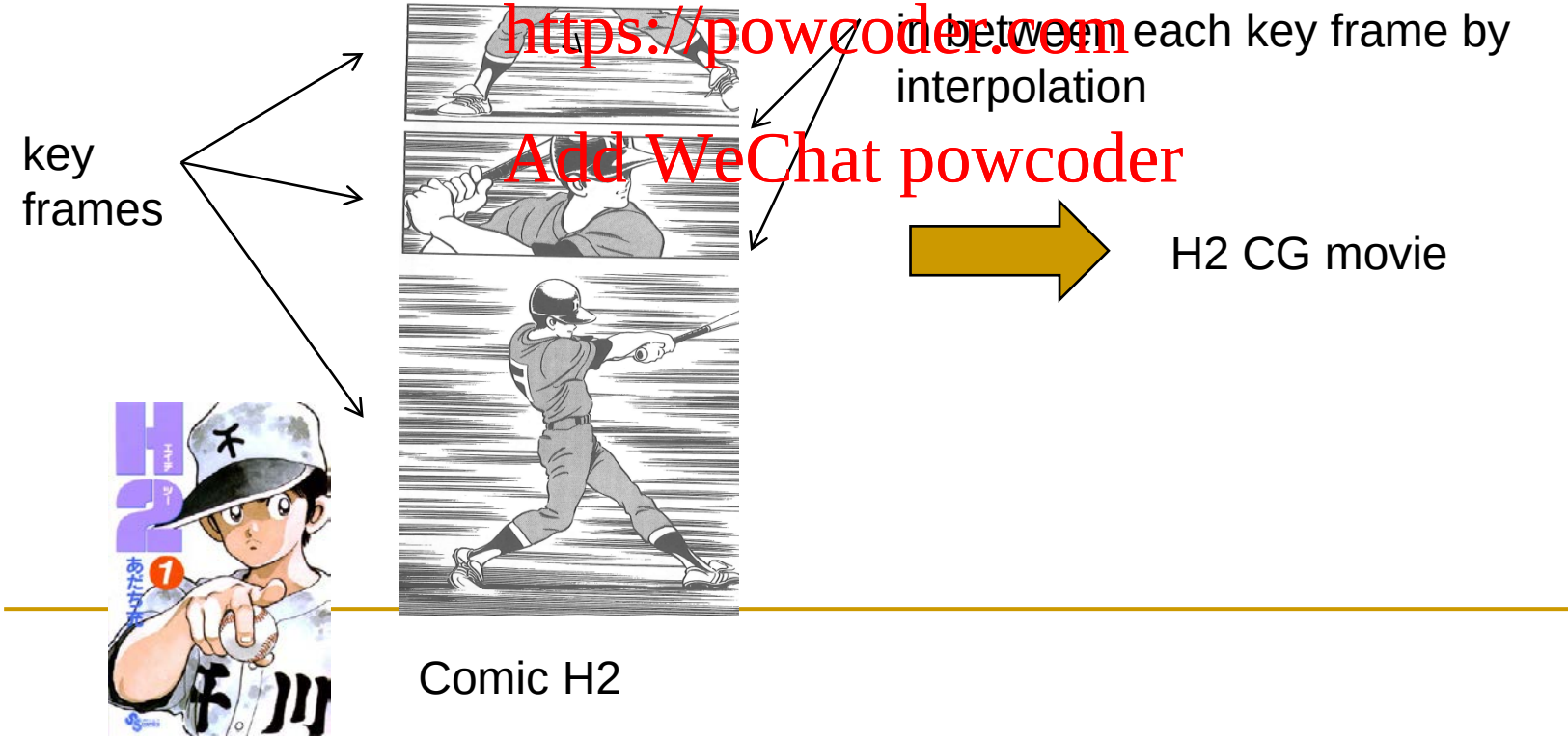
- Computer Art
  - new type of painting
  - New type of art form
  - …

"Butterfly 6228" Author: Human and Computer

Full-body anime generation with Generative Adversarial Nets (GAN)

Converting movie to cartoon and vice versa

- Movie to cartoon
- Cartoon to movie



CG in Hong Kong

- CG forum
  http://www.cgvigual.com/forum/index.php

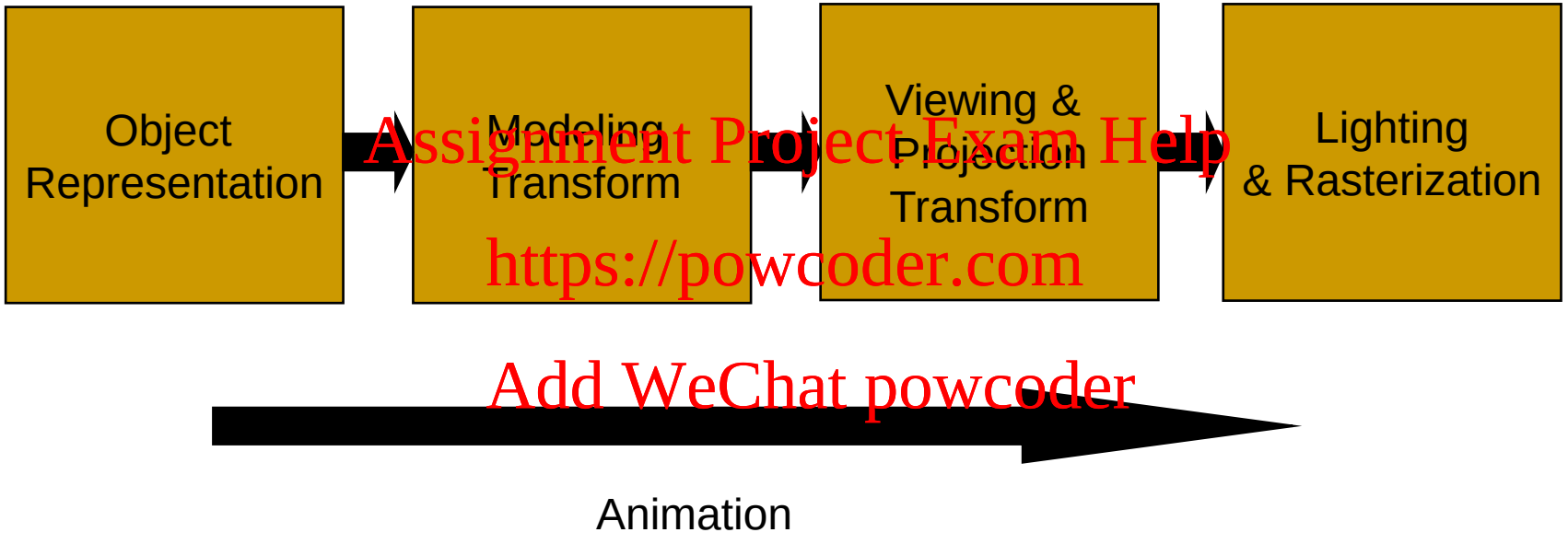
Course Aim

- The aim of this course is to provide students with an understanding of the basic principles, concepts, and techniques of computer graphics from an engineering viewpoint.

CILOS

- (CILO1) Apply 3D object representation techniques to build up a graphics scene
- (CILO2) Model and view articulated objects by hierarchical structuring techniques and coordinate transform
- (CILO3) Apply lighting, shading and rasterization techniques to create a 2D image
- (CILO4) Apply texture mapping and animation techniques to create a movie
- (CILO5) Apply and evaluate advanced graphics techniques
- (CILO6) Create an animation or a game using computer graphics

Course Content



Object Representation (CILO1)

Lecture 2

- How to construct simple objects such as spheres, cones, boxes ...

Modeling Transform (CILO2)

Lecture 3

- how to move the simple objects around, rotate them, scale them, reflect them, ...

Lecture 4

- introduce the idea of local coordinate system, and how to use the concepts to build a complex coherent moving object by using the hierarchy concept

Viewing and Projection Transform (CILO2)

Lecture 5

- how to put the camera in a desired configuration within the graphics scene and
- how to use different projections to project a 2D image on the camera, and as a result, the different projection effect that can be achieved

Lighting and Rasterization (CILO3)

Lecture 7

- how to create light sources, shading and colour

Lecture 8

- how to eliminate hidden parts

Lecture 9

- how to create realistic shadows

Animation (CILO4)

Lecture 6

- how to animate the images to create a smooth flowing movie

Advanced Graphics Techniques (CILO5)

Lecture 10

- How to create more realistic graphics by texture mapping

Lecture 11

- Sample of advanced techniques

OpenGL Mini Project (CILO6)

- This course uses the open source de facto industry standard: OpenGL, It is a C/C++ library that allows C programmers to write programs that directly access graphics hardware
- The gl and glut libraries

- How to learn OpenGL
  a) Learn during lecture, tutorial and mini project
  b) Search the web for the command
  c) OpenGL Function Index at the end of the text

Other forms of OpenGL

- Fixed function OpenGL is taught in this course first as it is the best for beginners. There are other forms of OpenGL

- WebGL - OpenGL JAVA version is popular
- OpenGL ES is used in iphone
- OpenGL shading language (GLSL) is used nowadays

Relationship of this course with commercial software

- Commercial software e.g. 3D studio

  used by game developers, many TV commercial studios and architectural visualization studios, movie effects etc.

- This course gives you the technical knowhow behind the techniques in these software. Thus
  - You can use them more sensibly
  - You know the limitations of these software and why
  - You acquire the background for more advanced state of the art knowledge (e.g. SIGGRAPH is the premier conference in CG)
  - You can create a new special effect not supported by the software or research your own novel effect
  - OpenGL is also a popular tool

Text Book and References

- Text book:

  Computer Graphics with OpenGL, Hearn and Baker, 4th Ed. (2011) Pearson (ISBN 10: 0-13-248457-9)

- Course Reserve has four copies. To access Course Reserve, go to CityU Library and select “Course Reserve”
- Course Reserve also has other useful supplementary reference material.

Assessment and Schedule

Assessment Tasks/Activities (ATs)

(ATs are designed to assess how well the students achieve the CILOs.)

Assessment Tasks/Activities	CILO No.						Weighting*	Remarks
	1	2	3	4	5	6		
Continuous Assessment: 50%								
Tests (min.: 2)	✓	✓	✓	✓			30%	
#Assignments (min.: 3)	✓	✓	✓	✓	✓	✓	20%	
Examination: 50% (duration: 2hrs, if applicable)								
Examination	✓	✓	✓	✓	✓		50%	
* *The weightings should add up to 100%.*							100%	

Remark:

To pass the course, students are required to achieve at least 30% in course work and 30% in the examination.

may include mini projects, in-class assignments, and homework assignments.

Coursework Components (50%)

Time	Item	Scope	Percentage
Tests			
Wk 6 (24 Feb.)	**Test 1**	everything taught in Wk 1-5	15%
Wk 11 (31 Mar.)	**Test 2**	everything taught in Wk 6 -10	15%
Assignments			
Wk 13 (21 Apr.)	**Mini-Project**		12.5%
	Other Assignments (at least 2)		5%
Wk 8 (10 Mar.)	**Mini-Project Progress**		2.5%

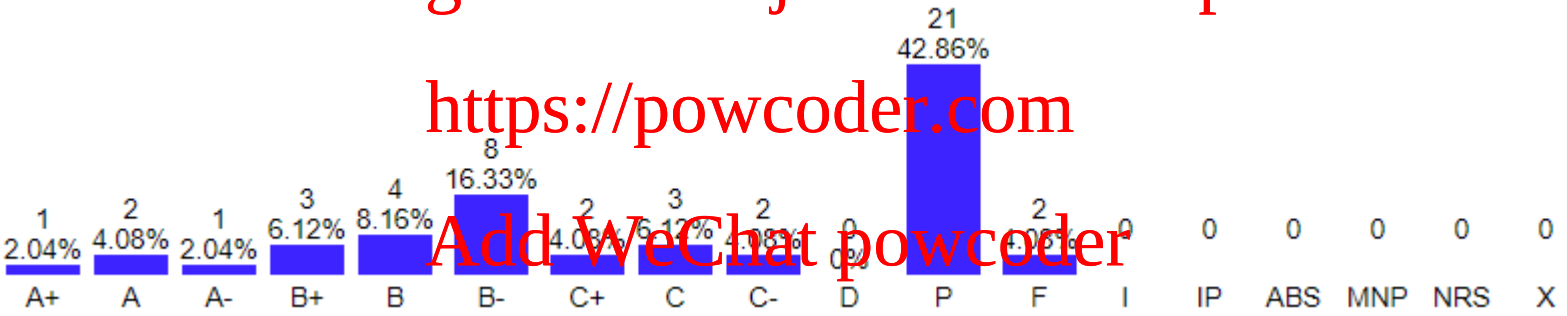
Guideline for mitigation request

- Departmental guideline: “For course assessment **work with weighting less than 20%** such as short quiz, test, etc., **make-up assessment will not be provided** to students. The students will score “0” for the assessment work concerned.”
- According to this guideline, no make-up assessment will be provided

Mini-project progress

- Hand in mini-project progress with
  - Realistic hierarchical structures
  - Realistic animation
- See mini project for the format
- No need to hand in report this time
- Hand in through Canvas. It will be opened for hand in

Grade distribution 19/20



If you have questions

- Please email me your questions during the week.
- We can also chat using Zoom. Please let me know when you would be available.

Teaching Assistant

Ms. LIU Wenwen

Office: FYW2386 Tel: 3442 9845

Email: wenwen.liu@my.cityu.edu.hk

Please email/phone to book an appointment

Mathematical Background

- You should have the mathematical background below:
  - 3D coordinate systems in Euclidean coordinates and polar coordinates
  - Basic matrix and vector arithmetic
  - Calculation of determinant
  - Scalar (dot) product: how to calculate and its physical meanings
  - Vector (cross) product: how to calculate and its physical meanings
  - Concepts of partial derivatives
- Please consult any standard text in Linear Algebra

Non-standard mathematical notation used

- **|N|** is normally used to denote the magnitude of vector **N** and is a scalar. In this course, **|N|** is sometimes also used to denote "normalize the vector **N** to a unit vector"

e.g. The light source is at (3, 3, 3) and the surface point is at (0, 0, 0). The unit lighting vector

$$L = |(3,3,3) - (0,0,0)| = \left(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}\right)$$