CMT107 Visual Computing

I.1 Introduction

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Overview

- Module Logistics
- Introduction to Visual Computing
- Applications

Prerequisites

- Mathematics
  - Basic Linear Algebra
  - Trigonometry
- Programming
  - Basic Data structures/Programming knowledge
  - Language: Java
  - Graphics API: OpenGL (No prior knowledge required)

Assessment

- Coursework: (30%)
  - Hand out: Week 5
  - Hand in: Week 10
- Written Examination: (70%)

Learning Outcomes

➢ Knowledge / Understanding

- Understand the concepts, techniques and underpinning technologies associated with Visual Computing.
- Critically analyse the present capabilities and limitations of Visual Computing algorithms and techniques.
- Demonstrate an understanding of the present state-of-the-art associated with specific aspects of Visual Computing.
- Design and implement simple algorithms to exercise and test elements of Visual Computing.
- Demonstrate an understanding of the underlying mathematical techniques.
- Understand the computational effort required to perform operations associated with various algorithms.

➢ Skills

- Programming of simple visual computing algorithms, including data handling.
- Critical evaluation of the claims associated with new algorithms and methods.
- Understanding of the computational burdens associated with different processing techniques and be able to select appropriate methods depending on the intended application and context.

Syllabus

- Introduction to Visual Computing
  - Concepts and Applications
  - Mathematics Review
- Computer Graphics:
  - Graphics systems
  - Graphics Programming and API
  - Transformations
  - Lighting and Shading
  - Texture mapping
  - Ray Tracing
- Geometric Modelling
  - Curves and Surfaces
  - Hierarchical Modelling
  - Geometric Operations
  - Boundary Representation (B-rep)
  - Mesh Representation
  - Constructive Solid Geometry (CSG)
- Image Processing
  - Image Representation
  - Image Filtering and Restoration
  - Mathematical Morphology
  - Image feature detection
- Computer Vision
  - Camera Models and Calibration
  - 3D Computer Vision
  - Object Recognition

Textbooks

- Main Textbooks
  - P. Shirley, M. Ashikhmin, and S. Marschner, Fundamentals of Computer Graphics, 3rd ed., A K Peters, 2009
  - M. Sonka, V. Hlavac, and R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson, 2008
  - F. Nielsen, Visual Computing: Geometry, Graphics, and Vision, Charles River Media, Inc., 2005

- Recommended Readings

  - D. Hearn, M.P. Baker, and W.R. Carithers. Computer Graphics with OpenGL, 4th Edition. Pearson Prentice Hall, 2011.

  - D. Shreiner, M. Woo, J. Neider, T. Davis. OpenGL Programming Guide: The Official Guide to Learning, 7th Edition. Addison Wesley, 2010.
  - R.C. Gonzalez and R.E. Woods, Digital Image Processing, 3rd ed., Pearson, 2008
  - D.A. Forsyth, J. Ponce, S. Mukherjee, and A.K. Bhattacharjee, Computer Vision: A Modern Approach, 2nd ed., Pearson, 2012
  - G.E. Farin and D. Hansford, The Essentials of CAGD, A K Peters, 2000

Websites

- Module website:

  https://learningcentral.cf.ac.uk/

- Graphics resources:

  http://www.opengl.org/

  http://jogamp.org/jogl/www/

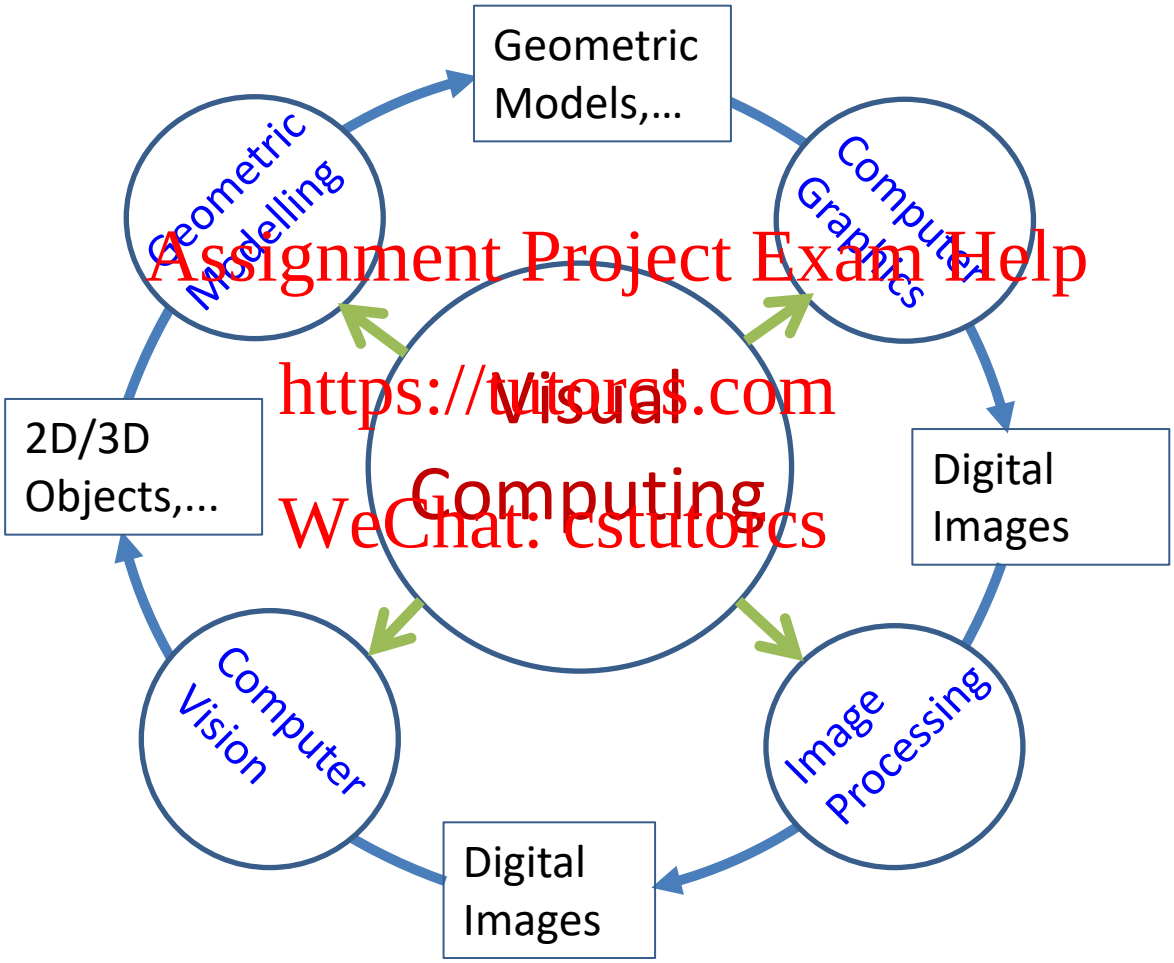
  http://www.siggraph.org/

Top Conferences

- SIGGRAPH: ACM SIGGRAPH Conference (since 1974)
  - **SIGGRAPH 2019: Technical Papers Preview**
  - **SIGGRAPH 2019: Emerging Technologies Preview**
  - **SIGGRAPH 2019: Computer Animation Festival Electronic Theater**
- I3DG: ACM SIGGRAPH Interactive 3D Graphics (since 1987)
- CVPR: IEEE Conf on Comp Vision and Pattern Recognition (since 1988)
- ICCV: Intl Conf on Computer Vision (since 1987)

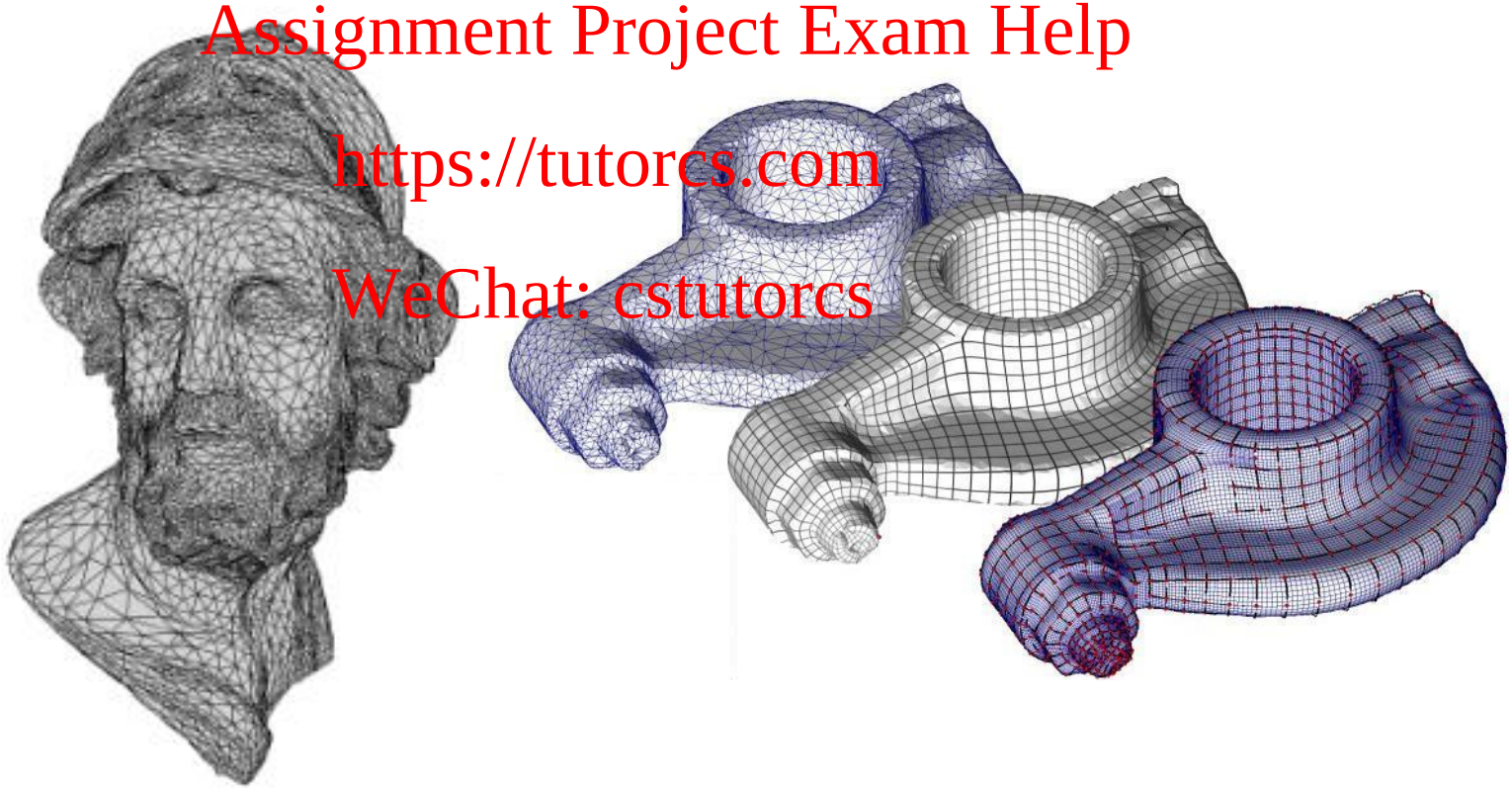
Visual Computing

- Visual Computing is a broad area of acquiring, creating, processing, analysing, and synthesising visual data by means of computers.



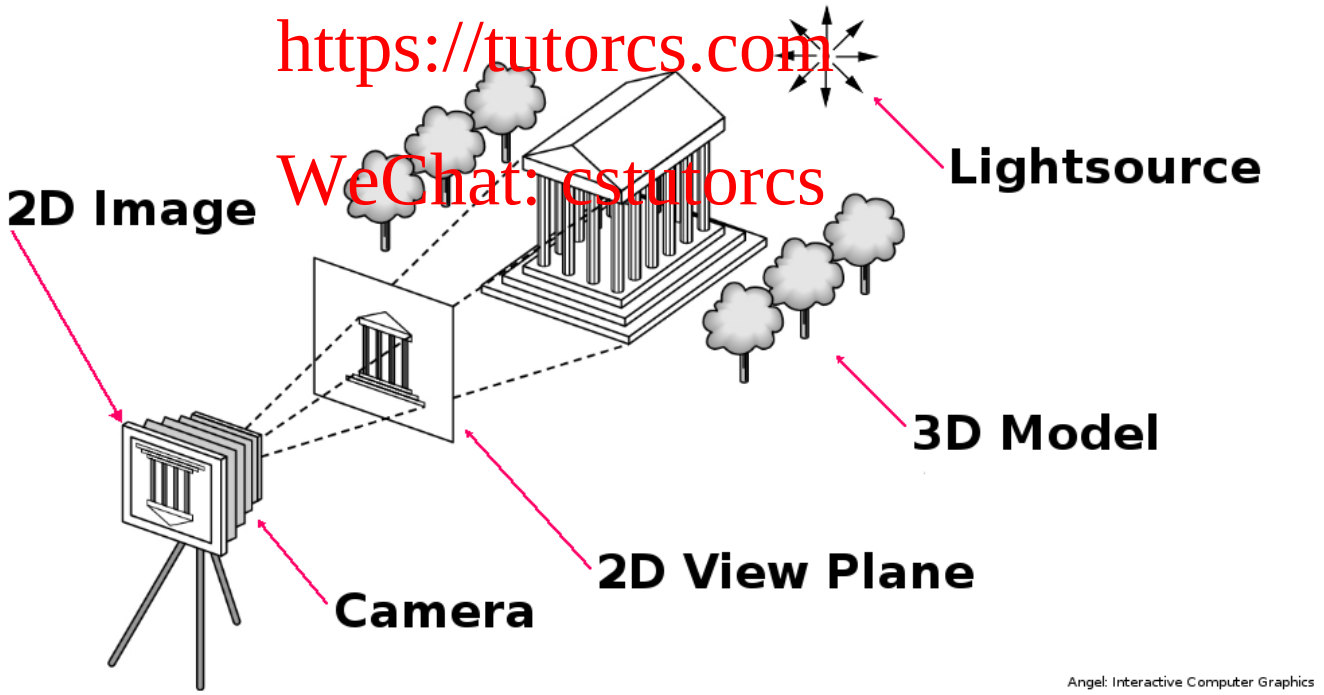
Geometric Modelling

- Geometric modelling is a subject of studying methods and algorithms for the mathematical description of shapes.
  - The shapes studied in geometric modelling are mostly two- or three-dimensional, although many of its tools and principles can be applied to sets of any finite dimension.



Computer Graphics

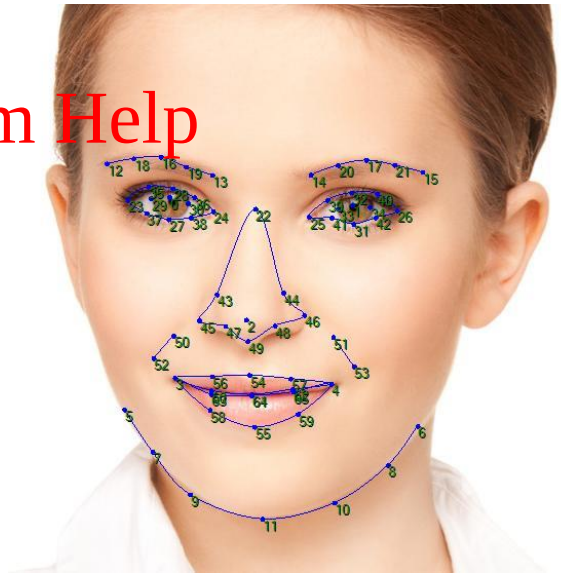
- Computer graphics is the art and science of representing and manipulating information using images generated through computation.
  - Imaging: capturing and manipulating 2D images
  - Modelling : representing and manipulating 3D objects
  - Rendering : creating 2D images from 3D models
  - Animation : simulating image changes over time with object motion



Angel: Interactive Computer Graphics

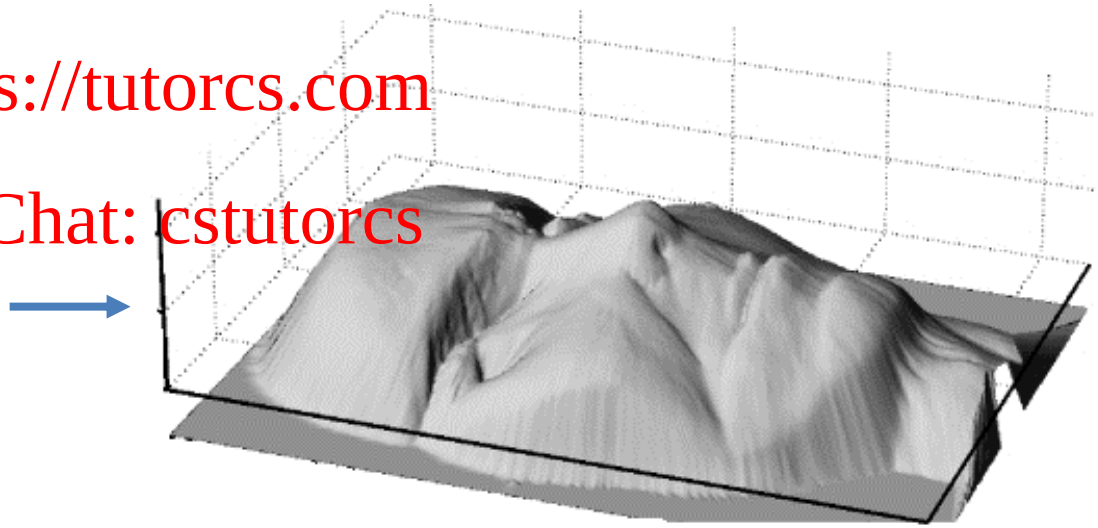
Image Processing

- Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame, and the output may be either an image or a set of characteristics or parameters related to the image.



Computer Vision

- Computer vision is a field that includes methods for processing, analysing, and understanding images in order to produce numerical or symbolic information, e.g., in the forms of decisions.
  - The boundary between image processing and computer vision is blurred sometimes.

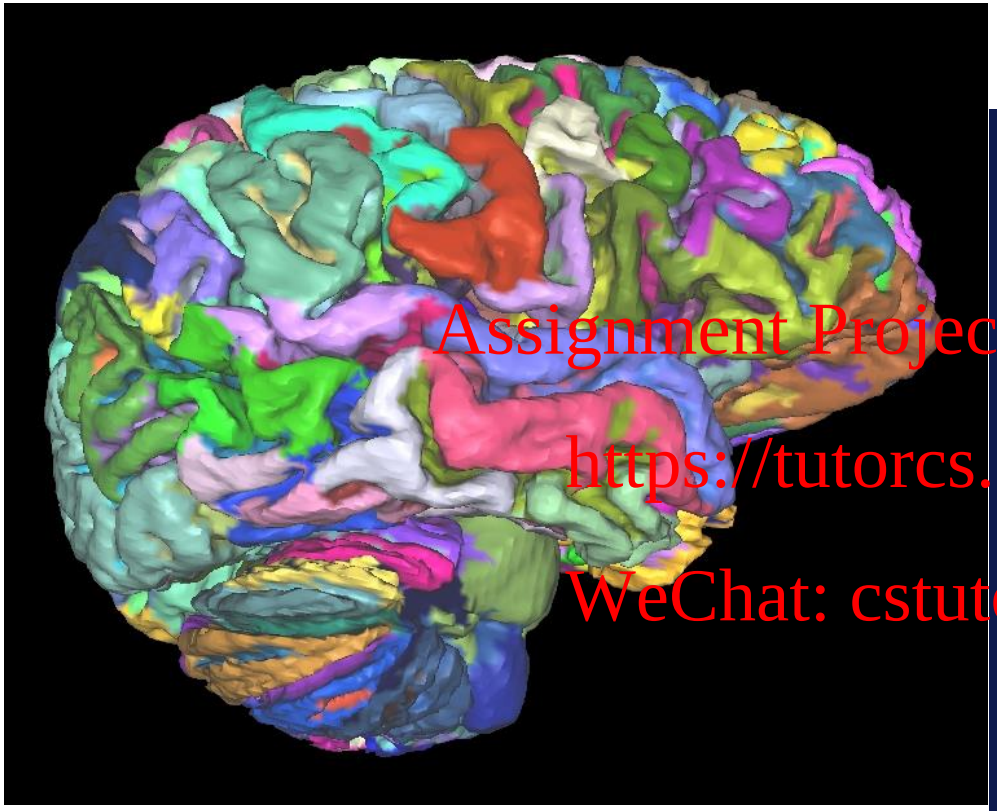


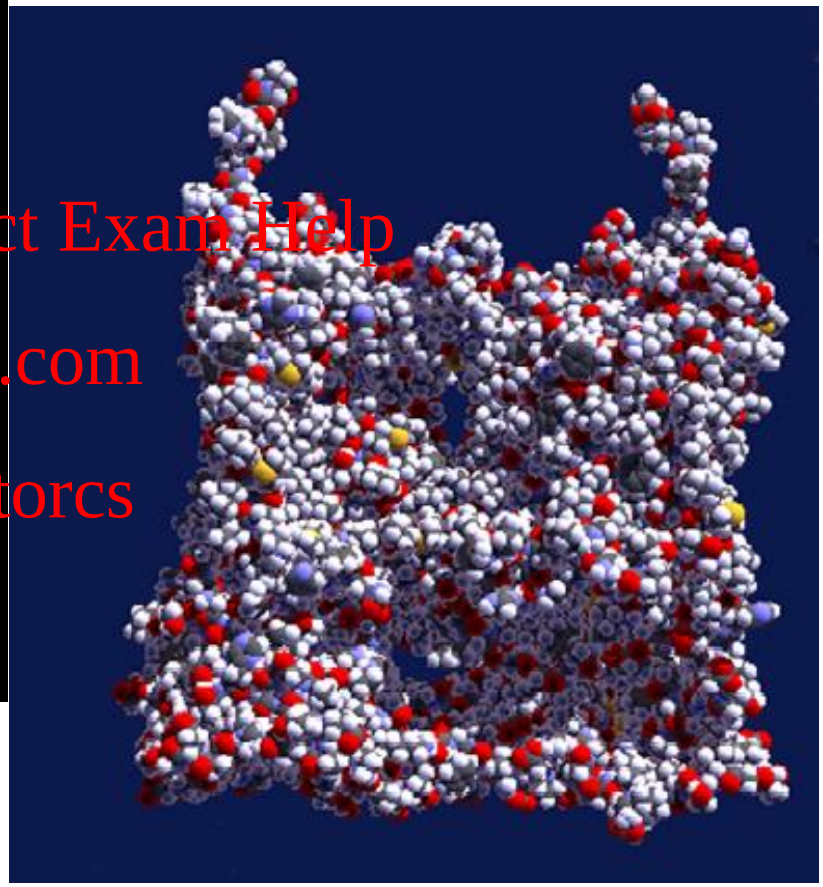
Applications

- Graphics generation
  - Visualisation of data (accurate non-realistic images)
  - Photo-realistic images (inaccurate)
  - Non-photo-realistic images, paintings
- Dynamic graphics: simulation and animation
  - Visualisation and simulation of processes
  - Realism and virtual environments
- Entertainment
  - Games, film special effects
- Industrial applications
  - Visual navigation, surveillance, biometric identification, …
- Design
  - Creating, modelling, editing and representing objects
- User interfaces
  - Suitable interactive environments

Visualisation of Data

accurate non-realistic images



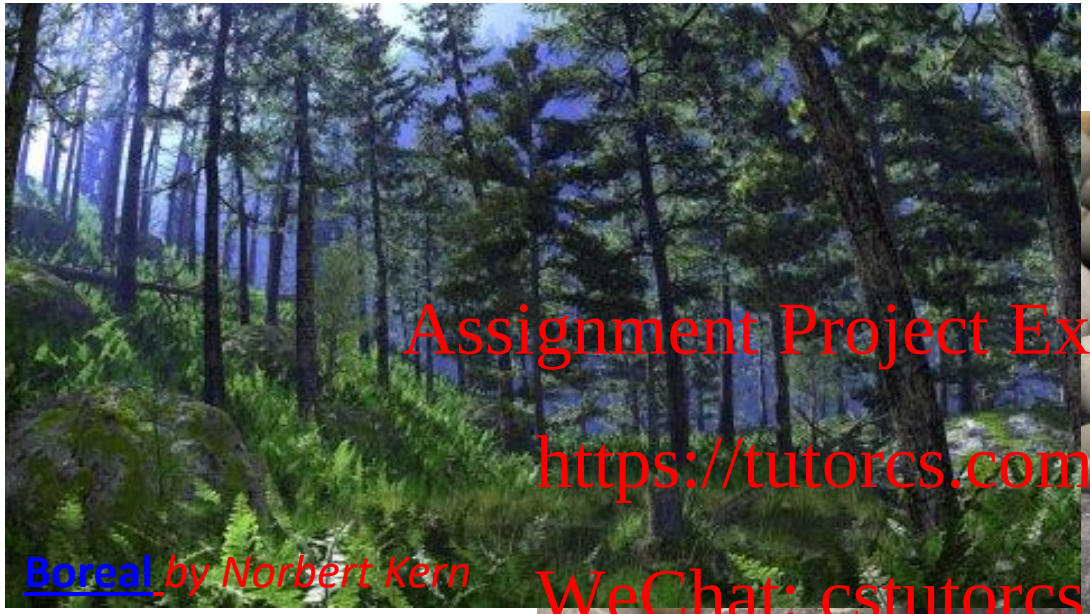


http://stubber.math-inf.uni-greifswald.de/~linsen/research/index_en.html

From MIT

Photo-realistic Image

inaccurate



Boreal *by Norbert Kern*

Generated using POV-**Ray**

Pebbles *by* ***Jonathan Hunt***

Non-photo-realistic Image

by Paul Rosin

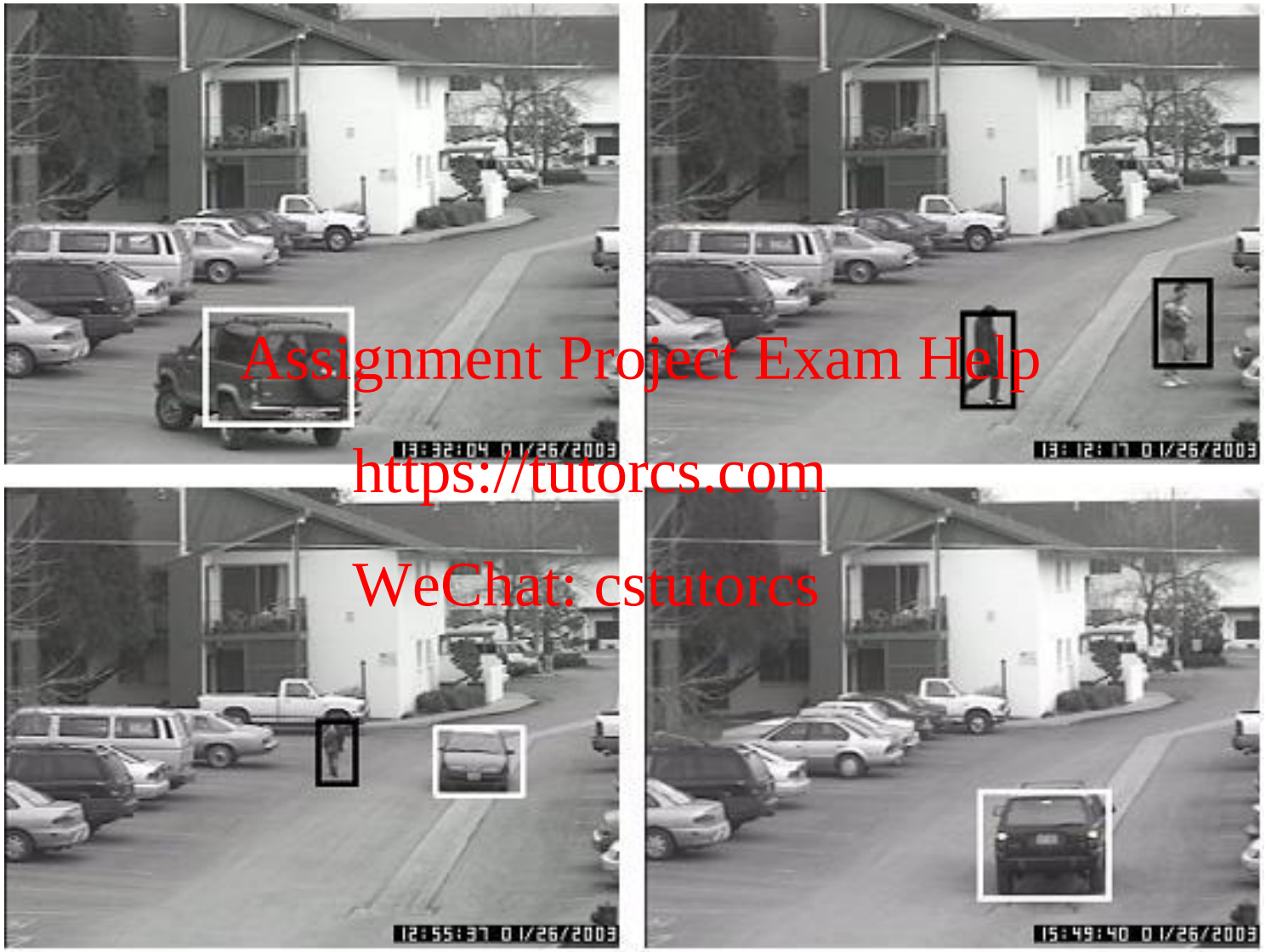
http://marctenbosch.com/npr_shading/fruitbowl.png

Simulation and Animation

From MIT

Entertainment

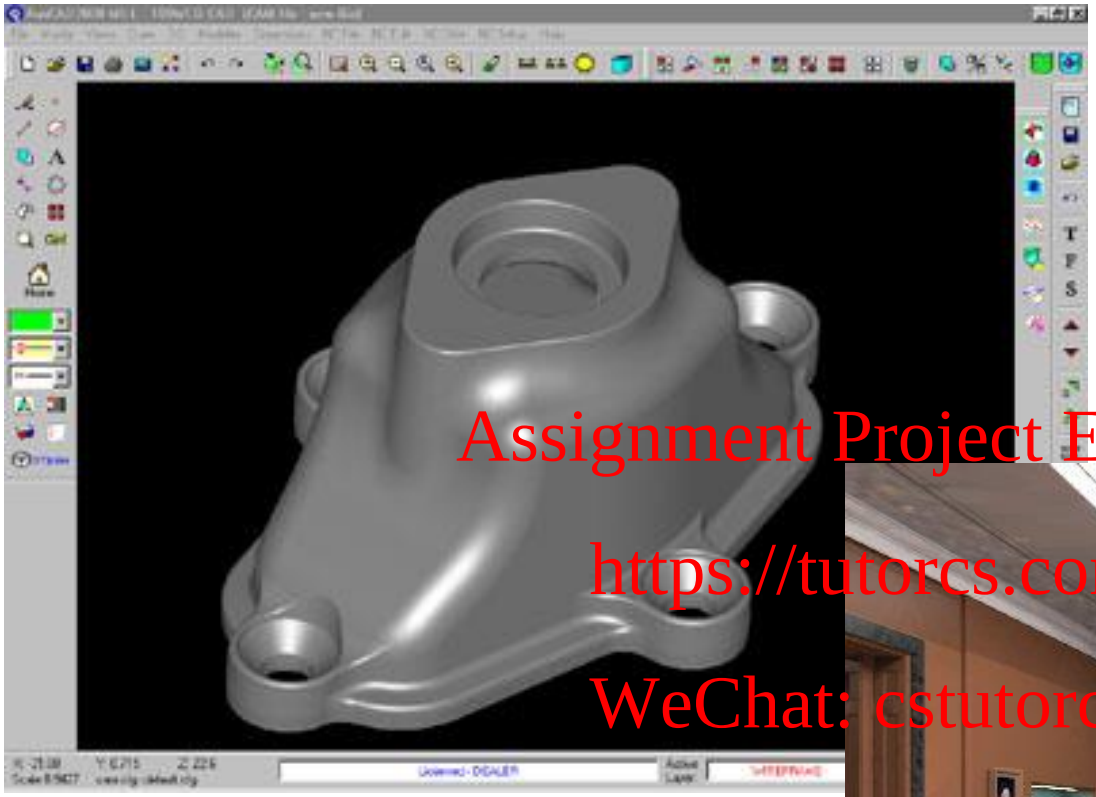
Surveillance



Autonomous Driving & Robot Navigation

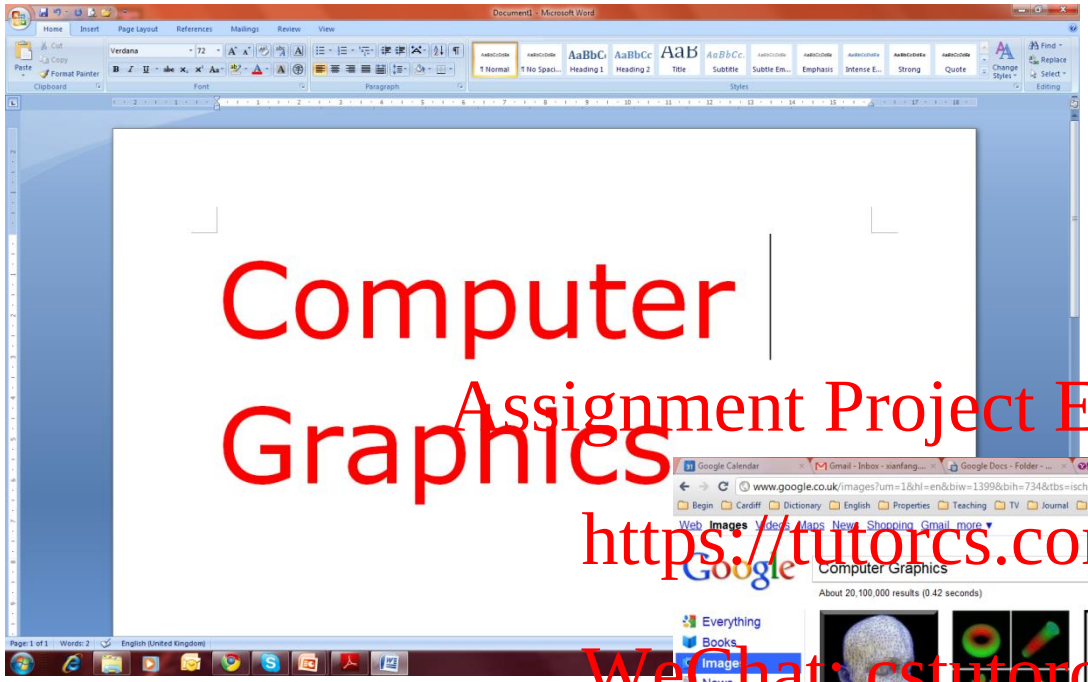
Biometric Identification

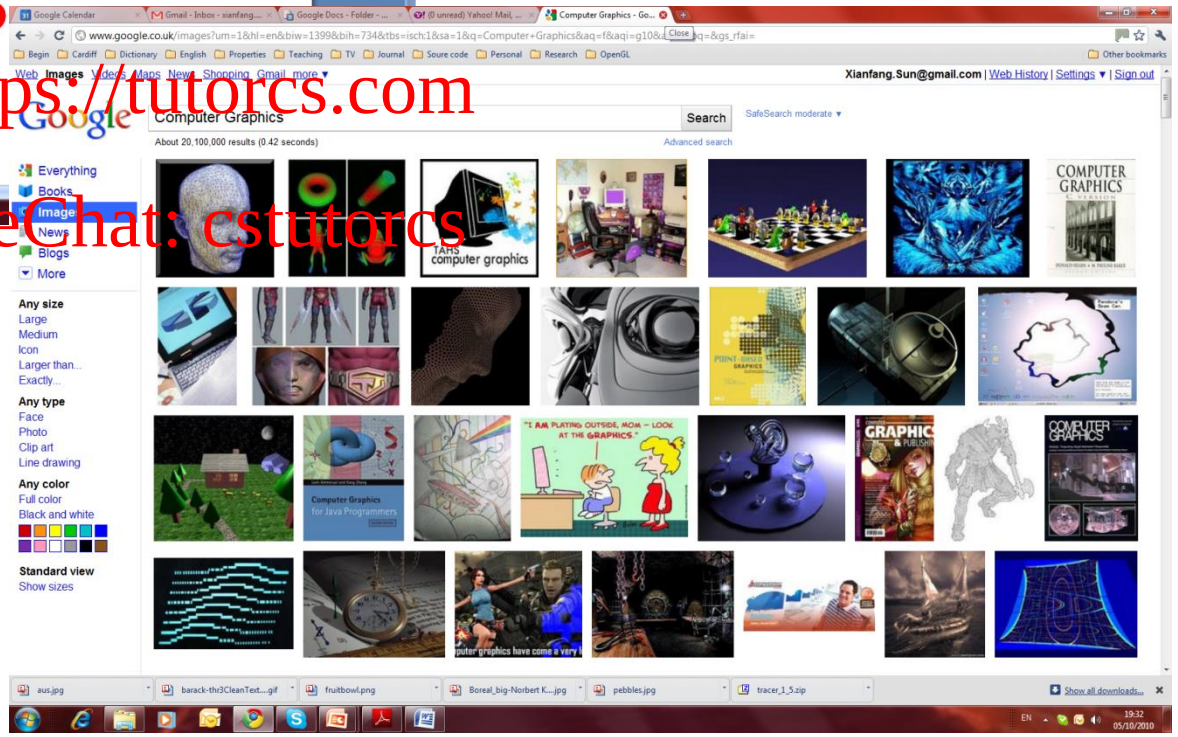
Design



freebyte.com

User Interface





Summary

- What is Visual computing?
- What is geometric modelling, computer graphics, image processing, and computer vision?
- Describe the relationship among the above-mentioned fields.
- List some examples of the applications of visual computing.