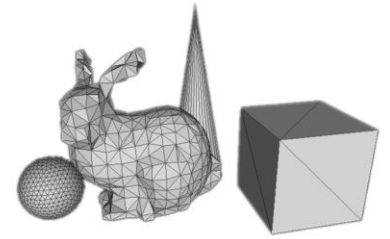


Introduction to Computer Graphics



Introduction

Contents(本节内容)

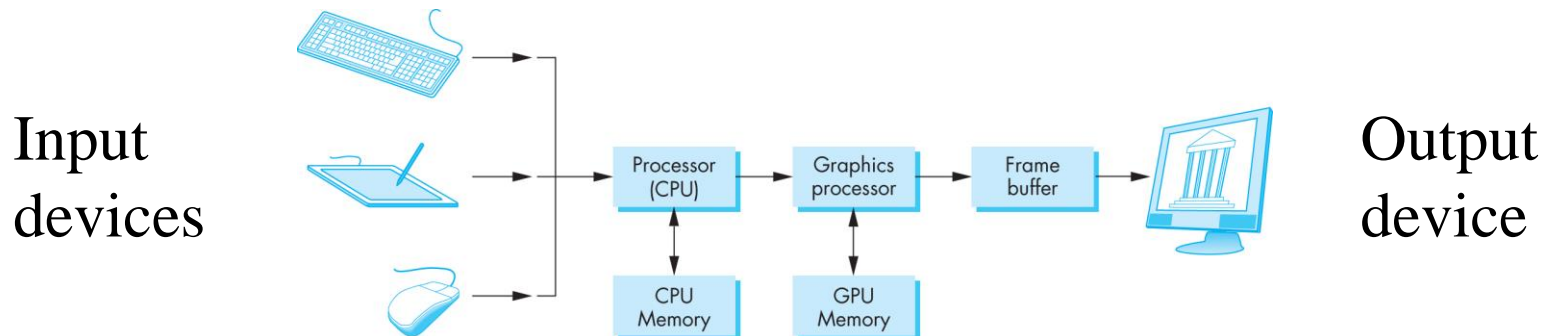
- What is CG (computer graphics)? 图形学是什么?
- Development History 历史发展
- Application areas 应用领域

Contents(本节内容)

- What is CG (computer graphics)? 图形学是什么？
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Computer Graphics

- *Computer graphics* deals with all aspects of creating images with a computer (研究利用计算机生成图像的方法)
 - Hardware 硬件
 - Software 软件
 - Applications 相关应用



Example

- How to create this image?



- What hardware/software did we need to produce it?

Preliminary Answer

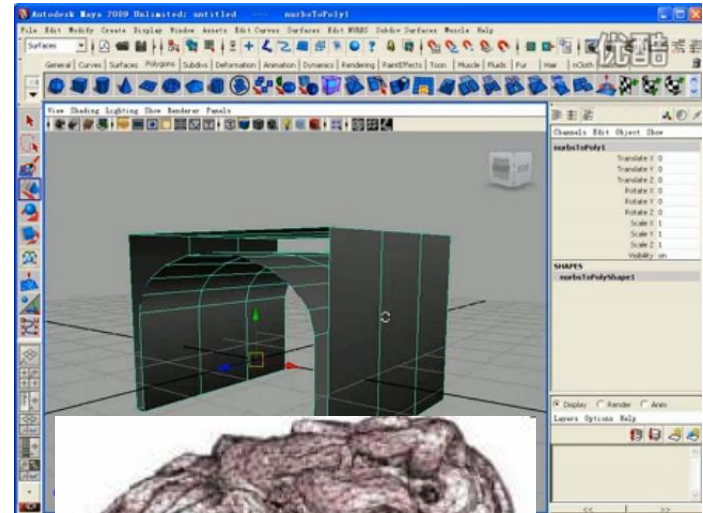
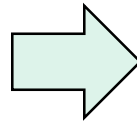
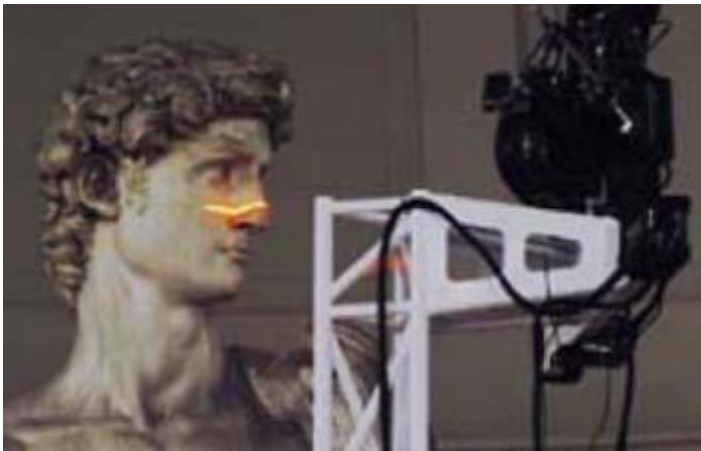
- **Software:** Maya for modeling and rendering but Maya is built on top of OpenGL
- **Hardware:** PC with graphics card for modeling and rendering

Main Research Contents (主要研究内容)

- Modeling (建模)
 - Create the 3D Objects (draw what)
- Rendering (绘制、渲染)
 - How to draw a image
- Animation (动画)
 - How to generate the moving/deforming objects
 - How to draw the object's motion

Modeling (建模)

- Create the 3D geometry
 - Generate
 - Reconstruct



Rendering (绘制)

- Creating the image
 - As realistic as possible
 - As cartoonlike as possible
 - ...



Animation (动画)

- Generating the image of moving objects
 - How to generate the moving/deforming objects
 - How to draw the object's motion
 - Obey the physics rules



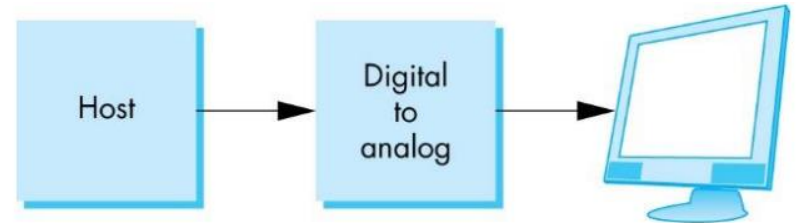
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Computer Graphics: 1950-1960

- Computer graphics goes back to the earliest days of computing

- Strip charts 条形图
- Pen plotters 笔式绘图仪



- Simple displays using A/D converters to go from computer to calligraphic CRT

画线CRT显示器（矢量CRT显示器）

- Cost of refresh for CRT too high
 - slow, expensive, unreliable

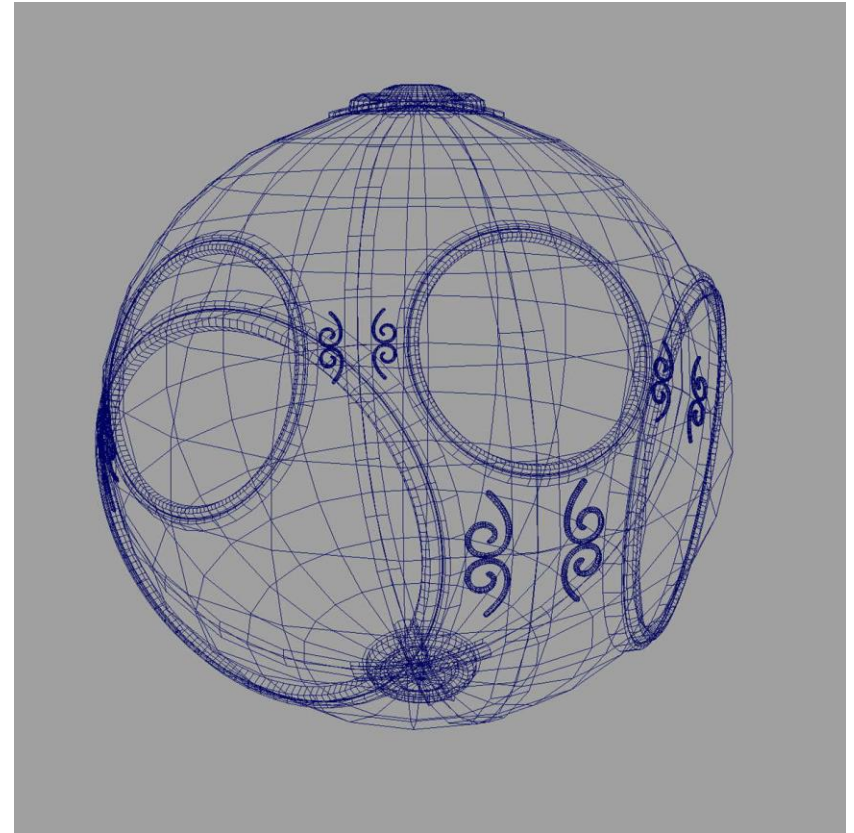
Pen plotters 笔式绘图仪



Computer Graphics: 1960-1970

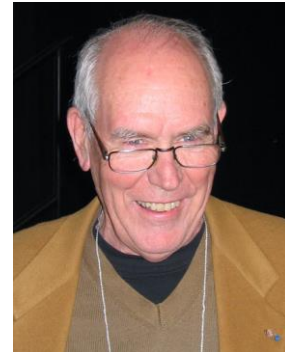
- *Wireframe* graphics
 - Draw only lines
- Sketchpad
- Display Processors

wireframe representation
of sun object

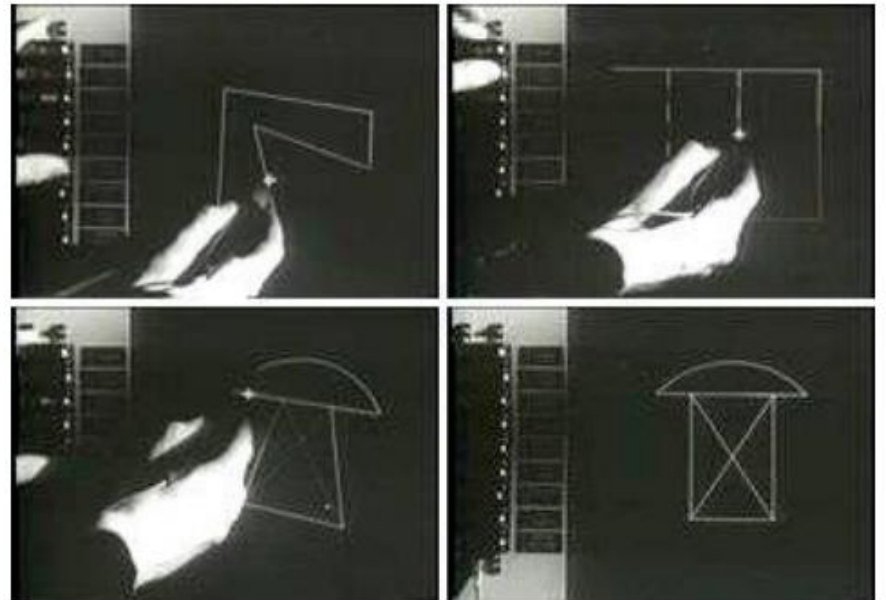


Sketchpad

- *Ivan Sutherland's* PhD thesis at MIT
 - Recognized the potential of man-machine interaction
 - Loop
 - Display something
 - User moves light pen
 - Computer generates new display
 - Sutherland also created many of the now common algorithms for computer graphics

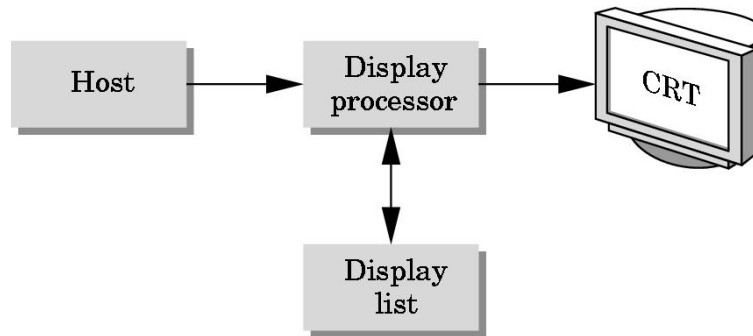


Sketchpad



Display Processor

- Rather than have the host computer try to refresh display use a special purpose computer called a *display processor* (DPU)



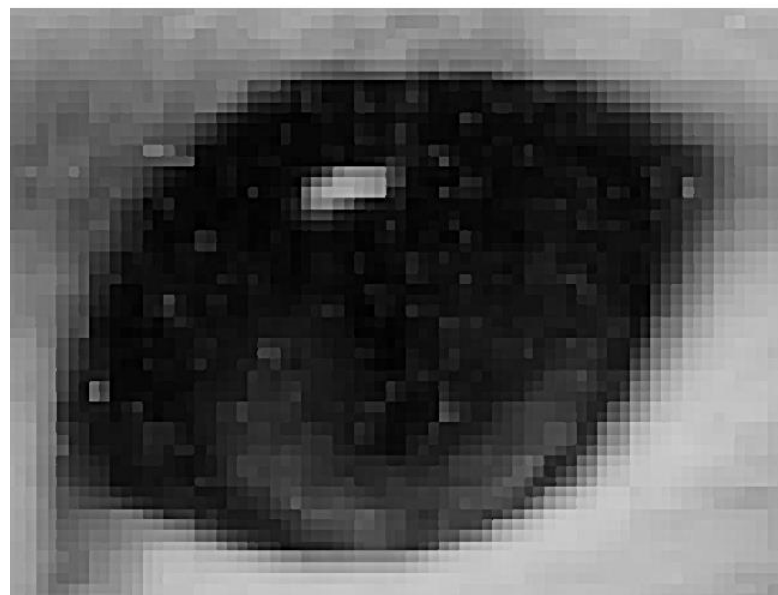
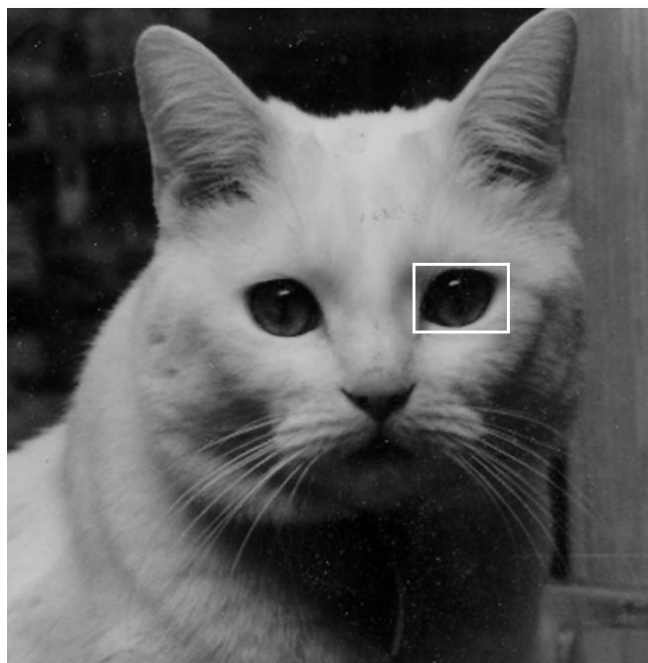
- Graphics stored in display list (display file) on display processor
- Host *compiles* display list and sends to DPU

Computer Graphics: 1970-1980

- Raster Graphics 光栅图形学
 - Compare with vectorised graphics
- Beginning of graphics standards
 - GKS: European effort
 - Becomes ISO 2D standard
 - Core: North American effort
 - 3D but fails to become ISO standard
- Workstations and PCs

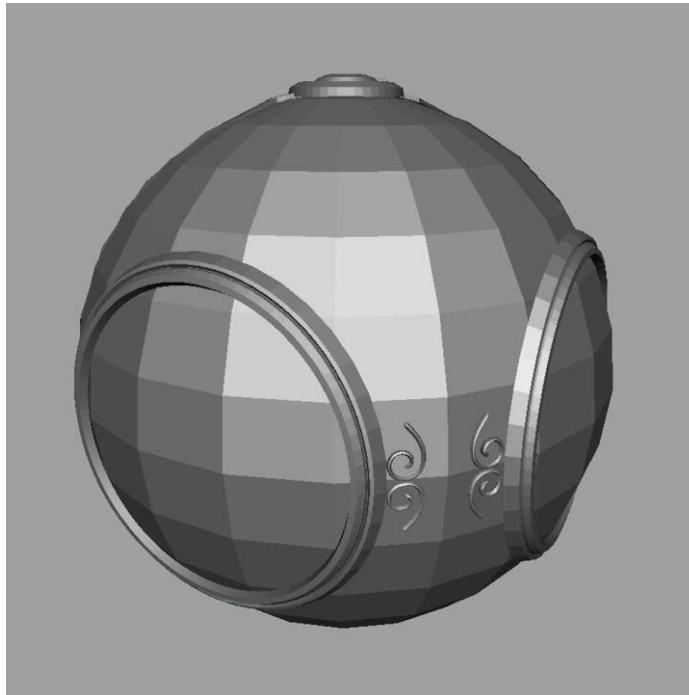
Raster Graphics

- Image produced as an array (the *raster*) of picture elements (*pixels*) in the *frame buffer*



Raster Graphics

- Allows us to go from lines and wire frame images to filled polygons

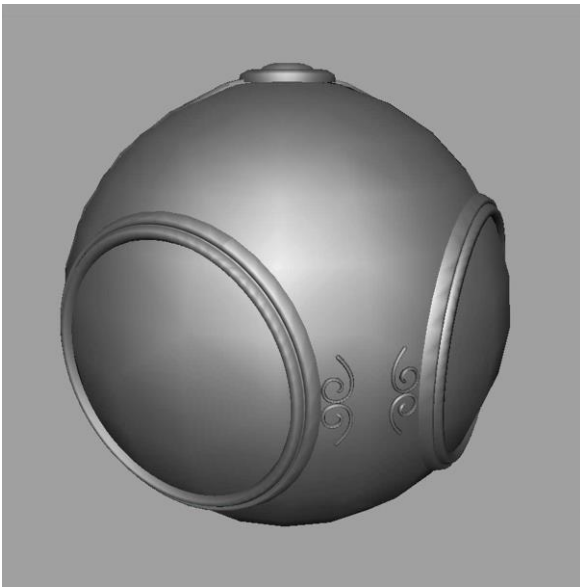


PCs and Workstations

- Although we no longer make the distinction between workstations and PCs, historically they evolved from different roots
 - Early workstations characterized by
 - Networked connection: client-server model
 - High-level of interactivity
 - Early PCs included frame buffer as part of user memory
 - Easy to change contents and create images

Computer Graphics: 1980-1990

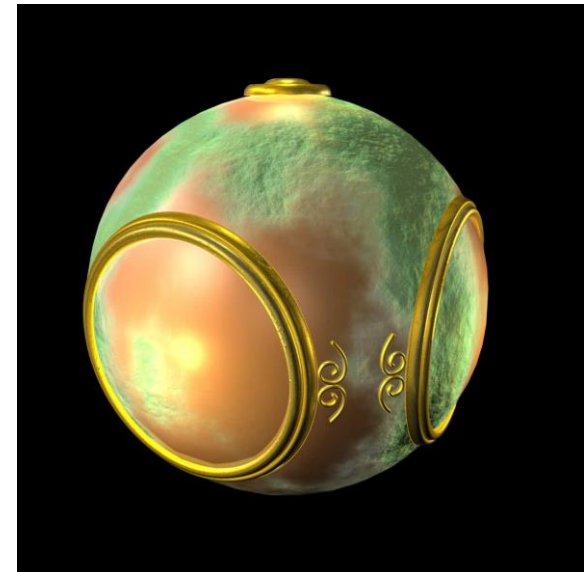
Realism comes to computer graphics



smooth shading



environment
mapping



bump mapping

Computer Graphics: 1980-1990

- Special purpose hardware
 - Silicon Graphics (Silicon Graphics, Inc. SGI) geometry engine
 - VLSI implementation of graphics pipeline
- Industry-based standards
 - RenderMan (皮克斯公司)
- Human-Computer Interface (HCI)

2020 Turing Award Winners



Catmull 和 Hanrahan

Computer Graphics: 1990-2000

- OpenGL API
- Completely computer-generated full-length movies (Toy Story) are successful
- New hardware capabilities
 - Texture mapping
 - Blending
 - Accumulation, stencil buffers

Computer Graphics: 2000-

- Photorealism
- Graphics cards for PCs dominate market
 - Nvidia, ATI
- Game boxes and game players determine direction of market
- Computer graphics routine in movie industry:
Maya, Lightwave
- Programmable pipelines
- GPGPU

Computer Graphics: 2015-

- AIGC
 - Digital Human
 - NeRF
 - Gaussian Splatting
 - GAN
 - Diffusion Model
 - Text-Video
 - Sora 2024



“macro shot of a leaf showing tiny trains moving through its veins”

Computer Graphics: 2015-

- AIGC
 - Digital Human
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"a giant duck walks through the streets in Boston"

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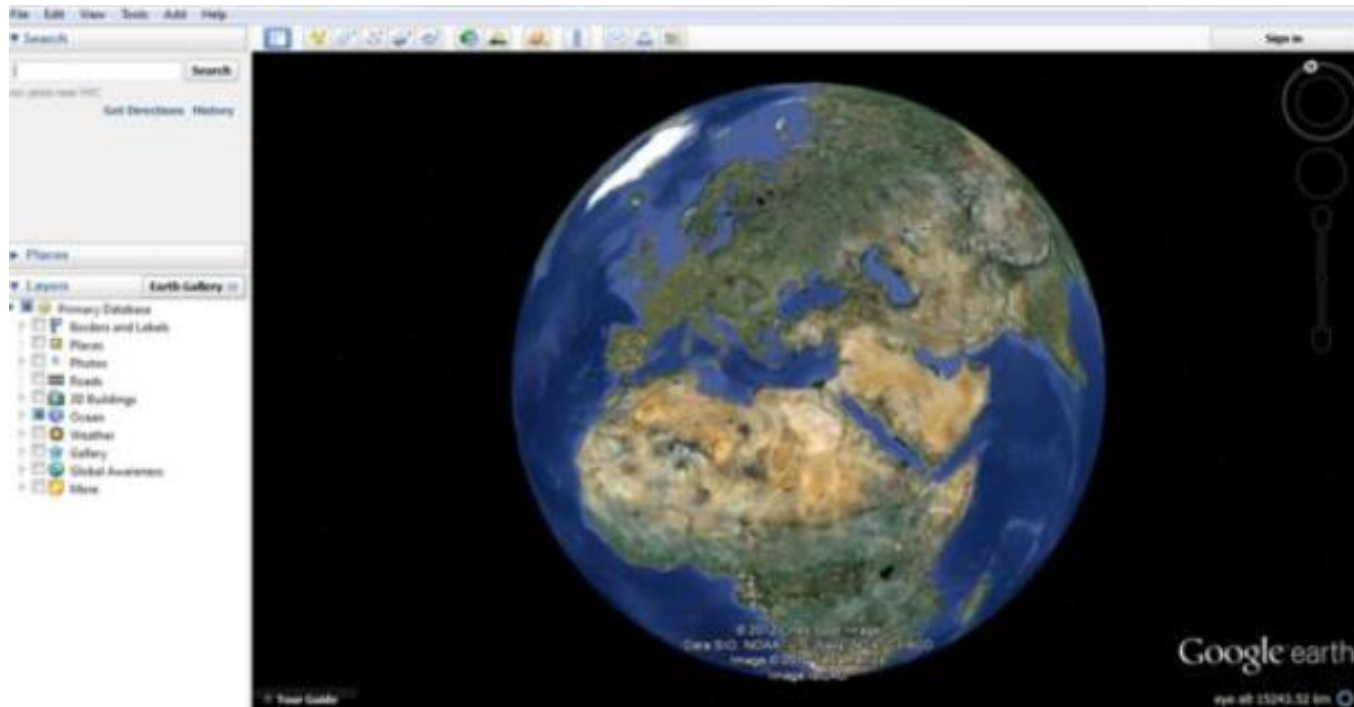
- What is CG (computer graphics)? 图形学是什么？
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Applications

- Visualization of Information (信息可视化)
- Design (设计)
- Simulation and Animation (模拟与动画)
- User Interface (用户界面)

Digital Earth and Digital Urban (数字地球与数字城)

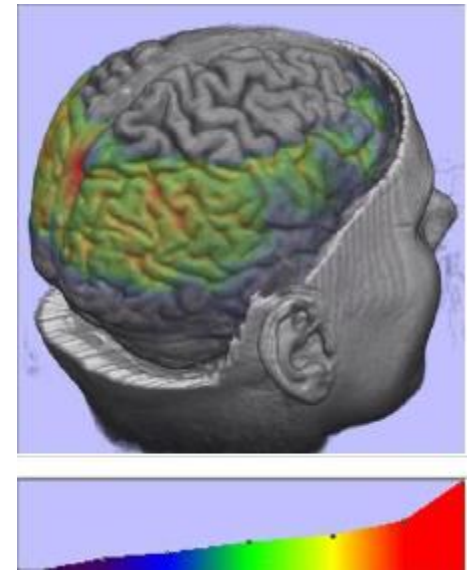
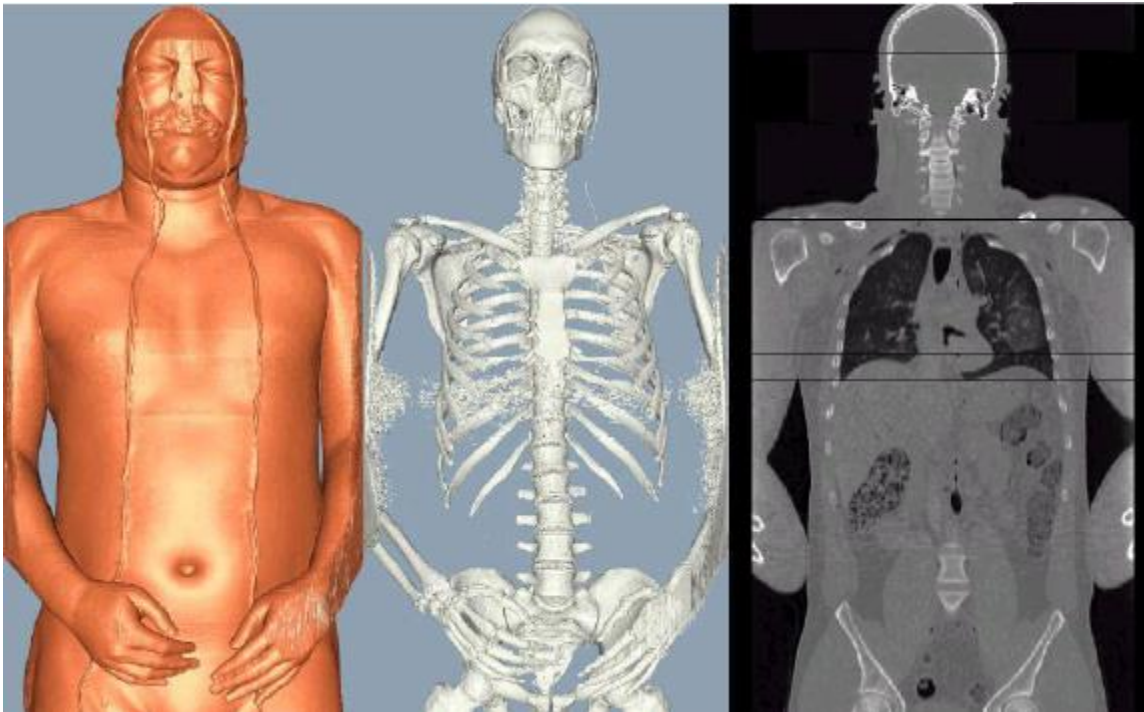
- Google earth
- Bing maps (previously Microsoft Virtual Earth)



Google Earth: 3D Urban

优酷

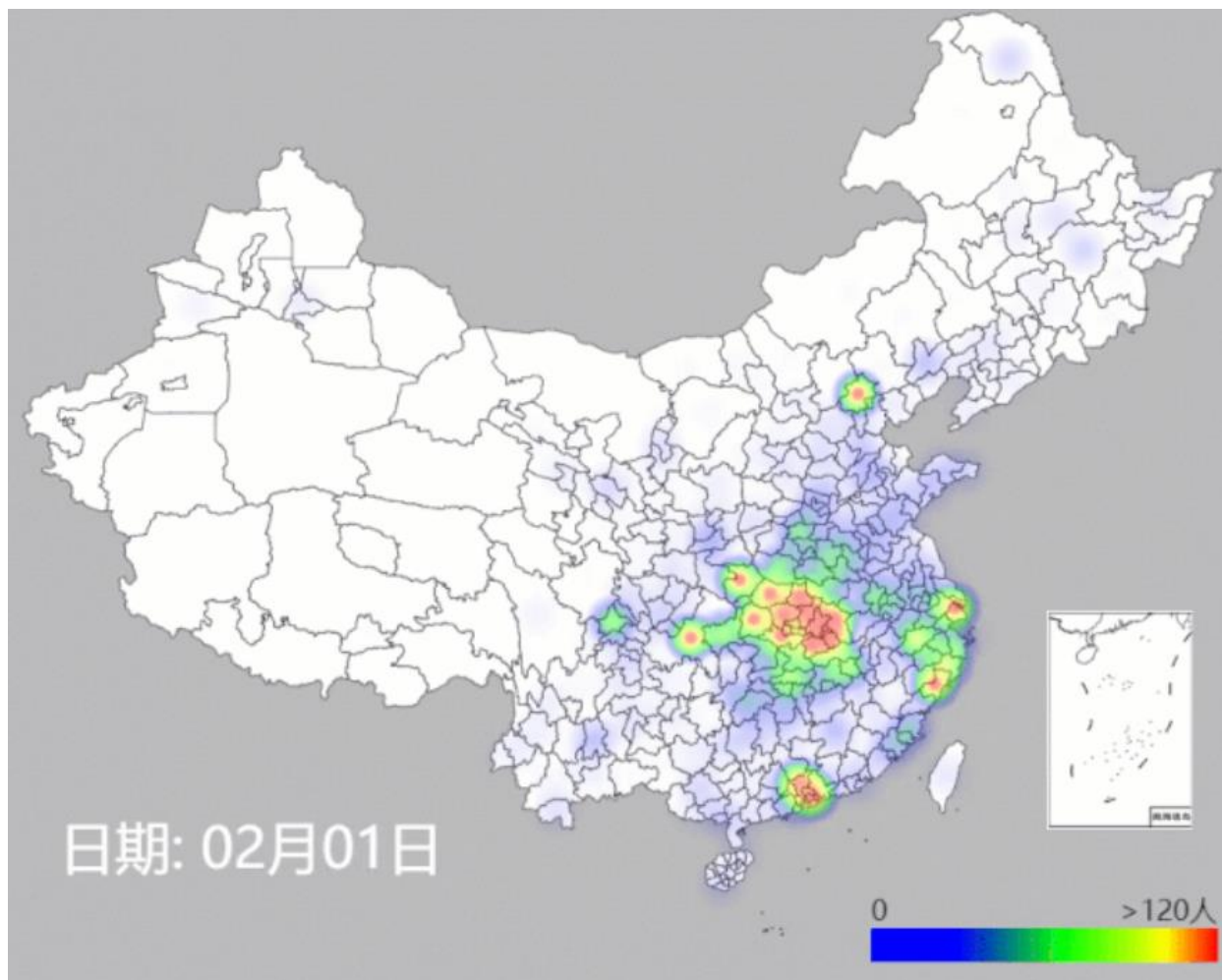
Medical Image (医疗图像)



Visualization of Big Data

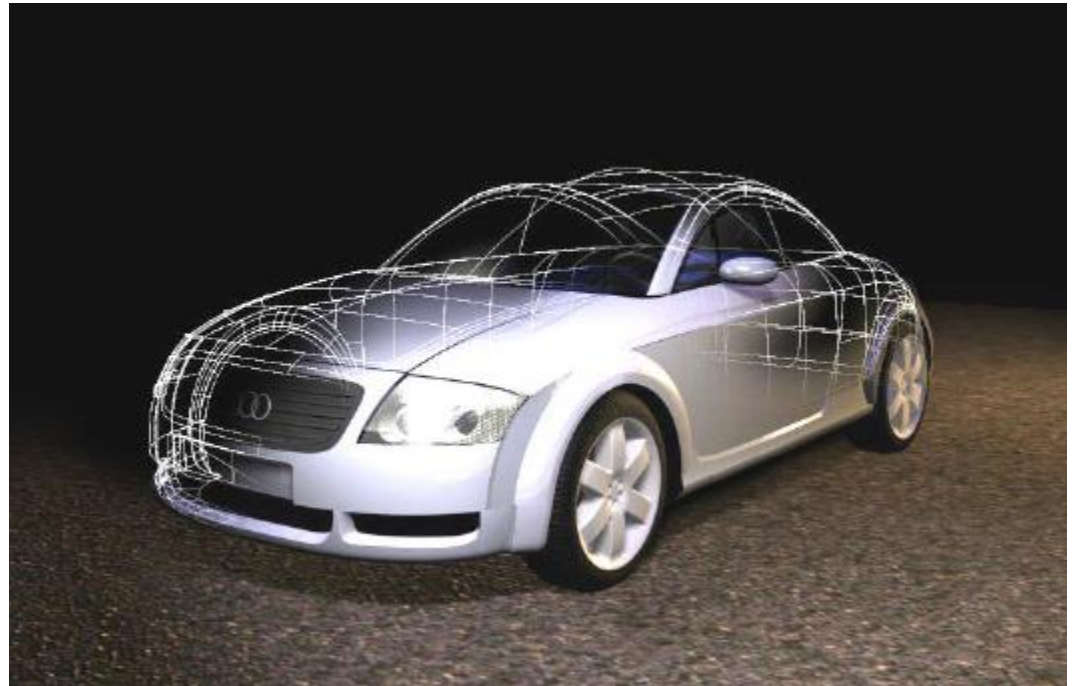
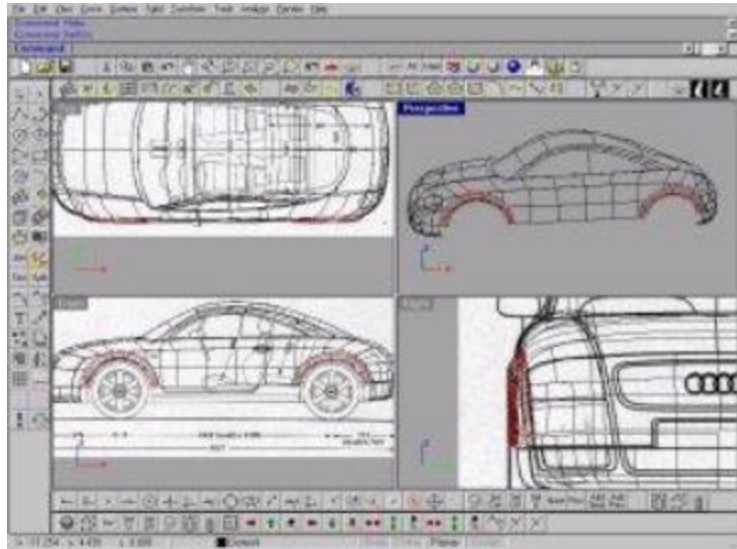


Visualization of Big Data

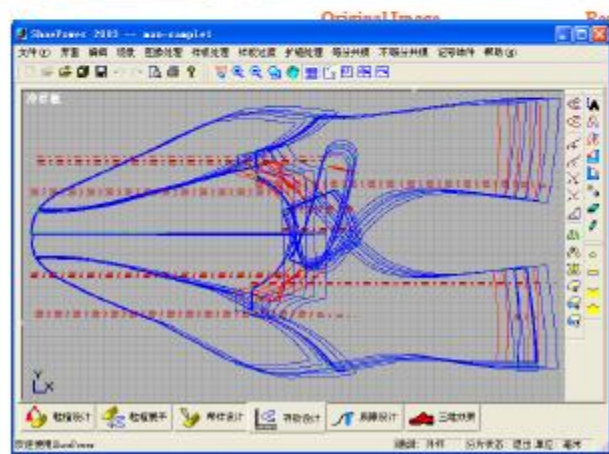
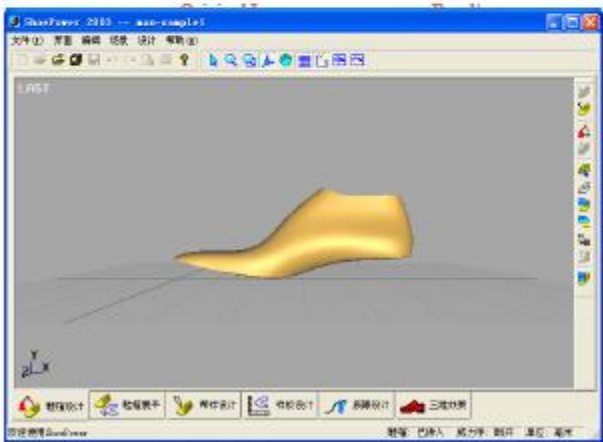


北大陈宝权教授团队

Design of Cars



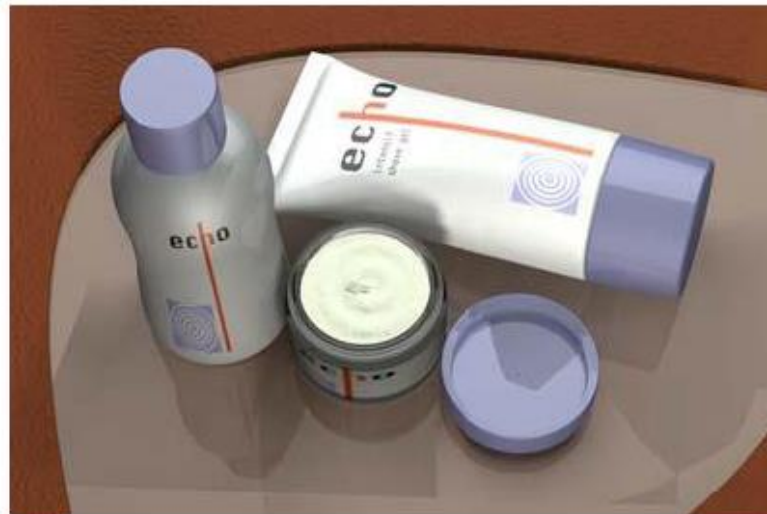
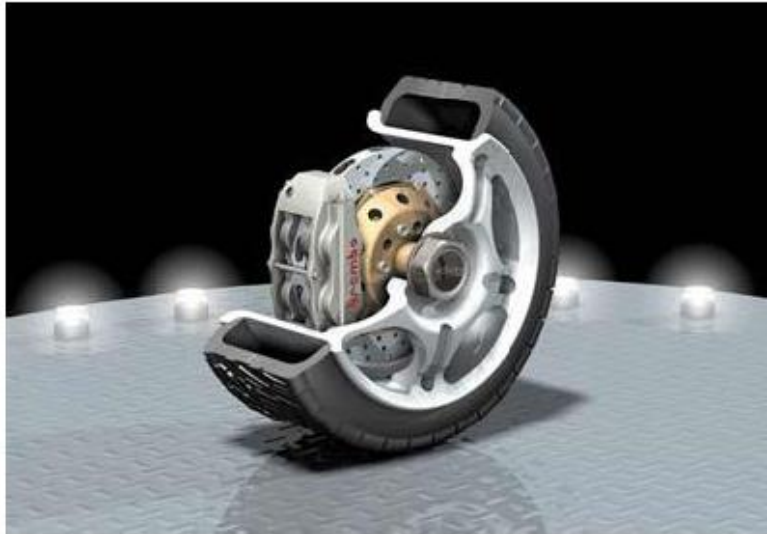
Virtual Design



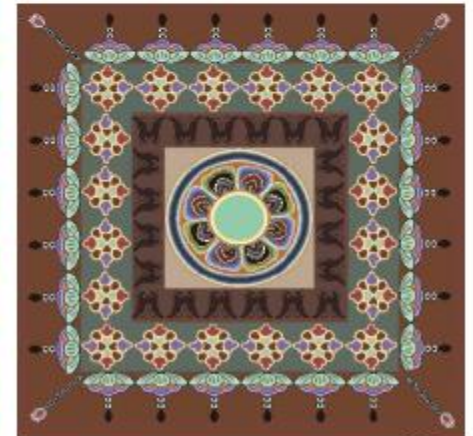
Virtual Try-on



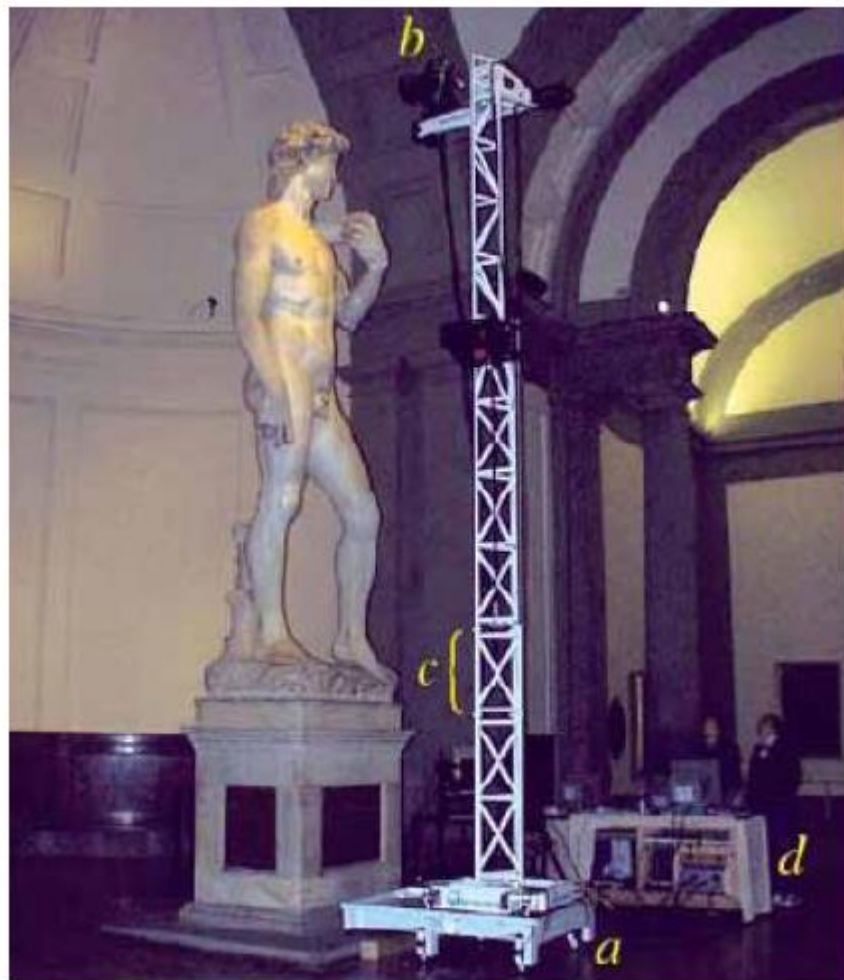
CAD/CAM



Computer Arts



Digital Heritage



Virtual Reality



Virtual Reality



Augmented Reality

- Microsoft's HoloLens



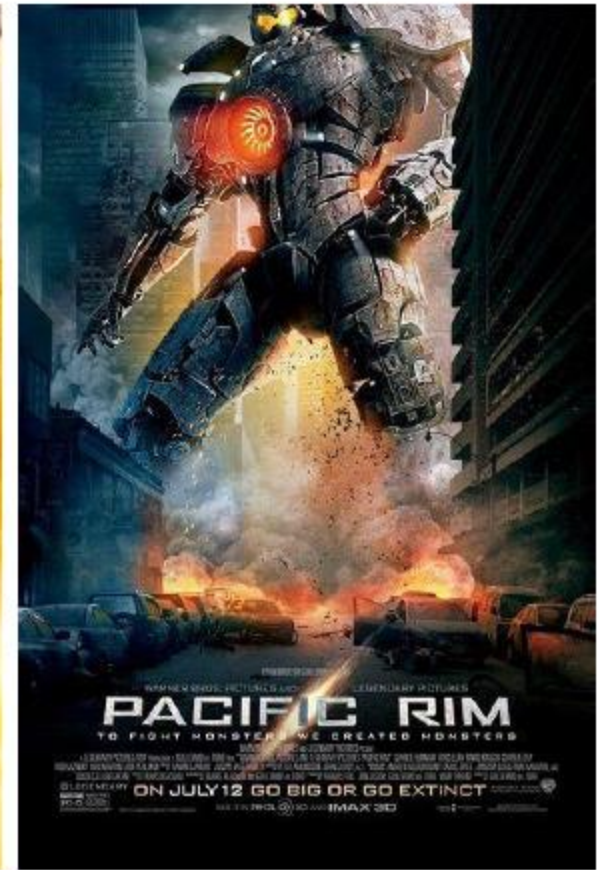
Computer Games



Animation



Movies



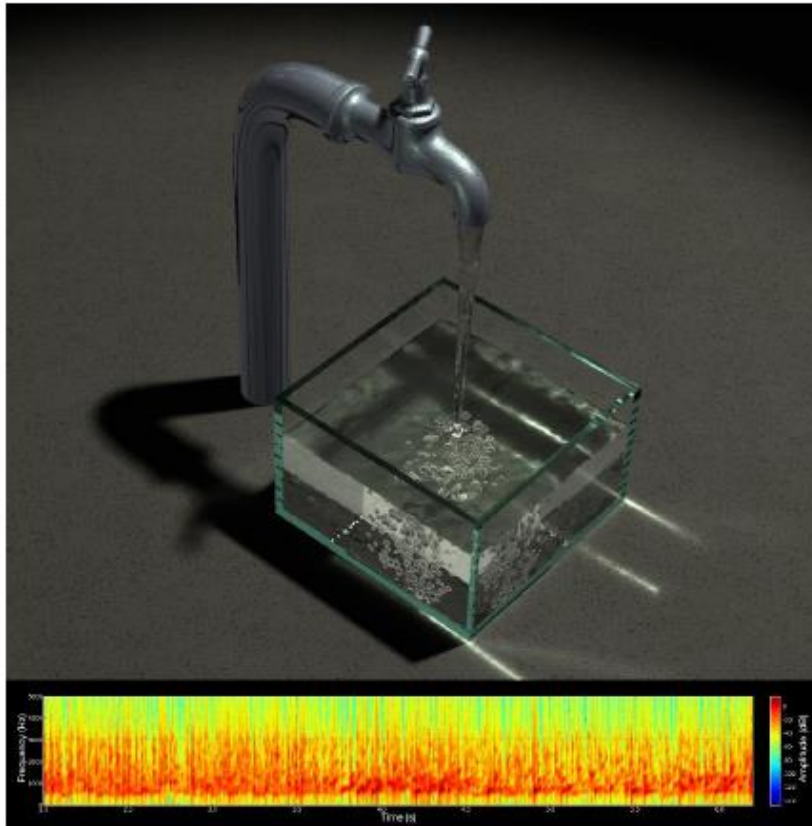
Visual Effects: Life of Pi

优酷

Visual Effects: The Adventures of Tintin

优酷

Simulation

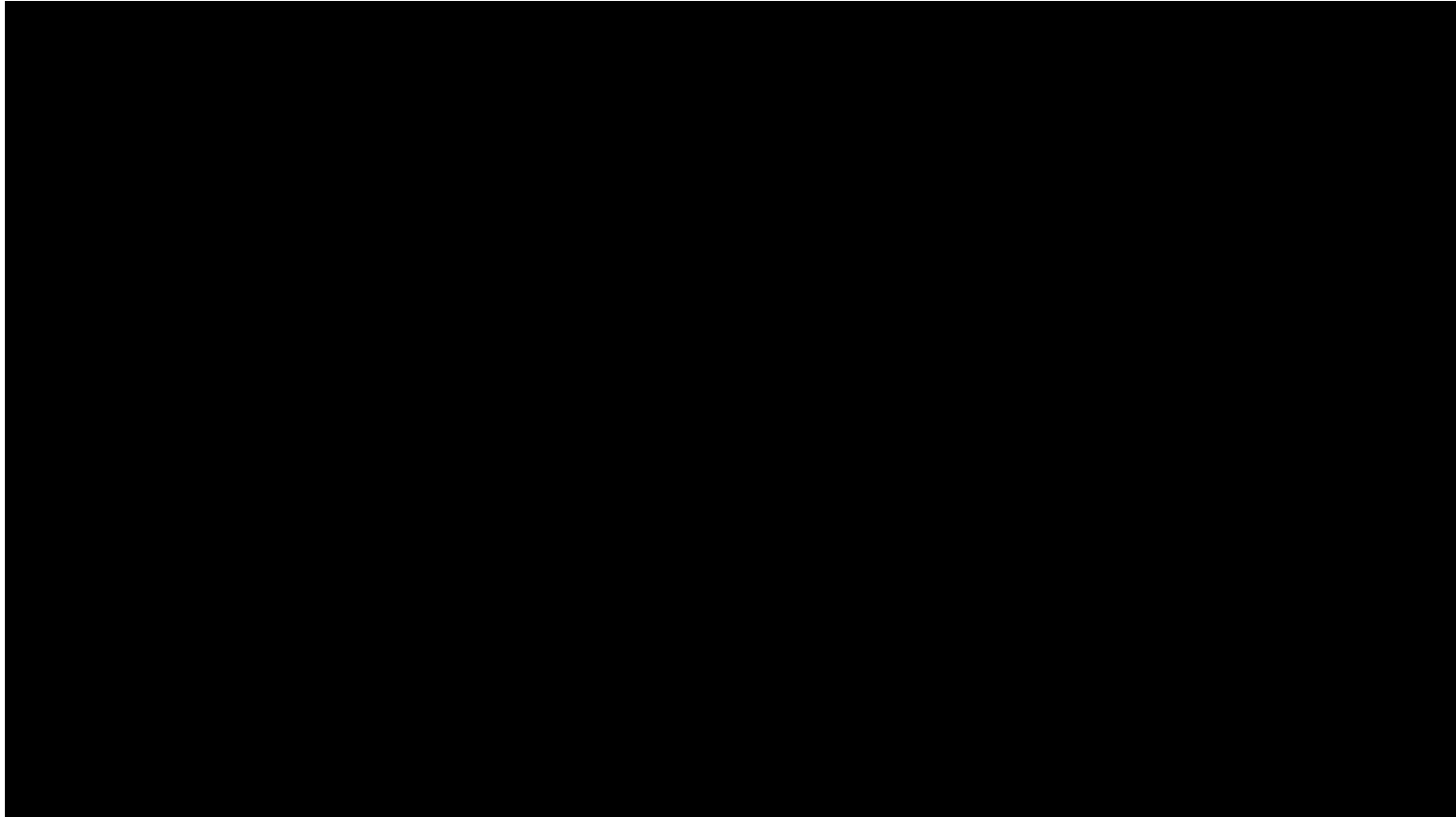


User Interface

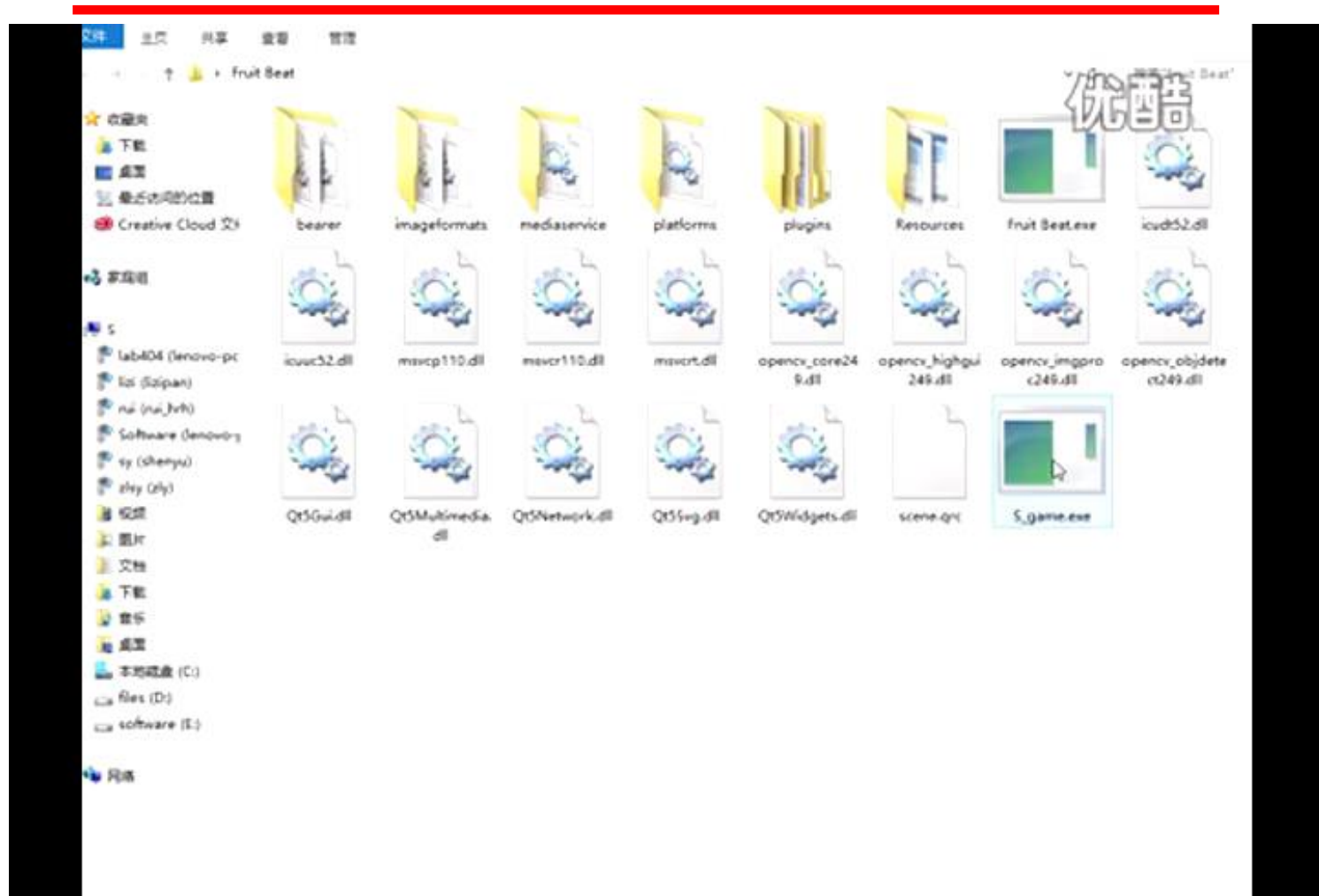


User Interface

- Kinect



Fruit Cut



3D Printing



3D Printing

优酷

CG / CV / AI

- CG: Generate an Image
- CV: Parse an Image
- AI:
 - The tools of CG/CV
 - The Path to CG/CV