Scientific Visualization

Lecture 7:
Other Visualization software

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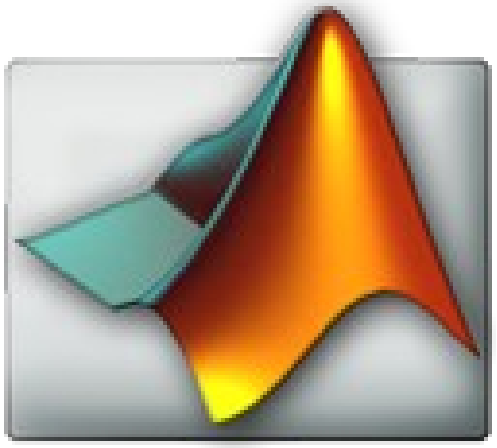
Today's lecture

- Ways to create visualizations using
  - Matlab
  - Blender



Opposite ends of the scale

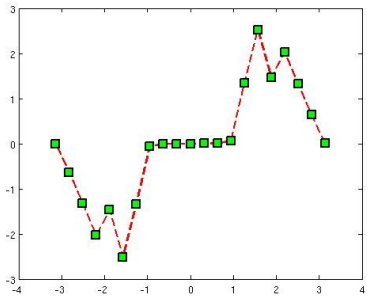
- Matlab
  - Scientific tool
  - Good for visualizing distributions of data
  - Expensive
- Blender
  - Open source 3D-modeling software
  - Free
  - Harder (but NOT impossible) to do ”exact” scientific visualizations

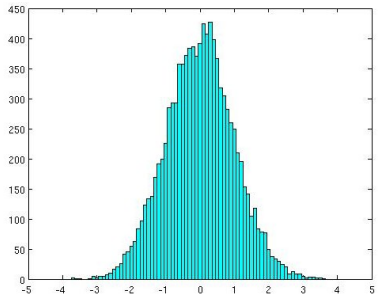
Matlab

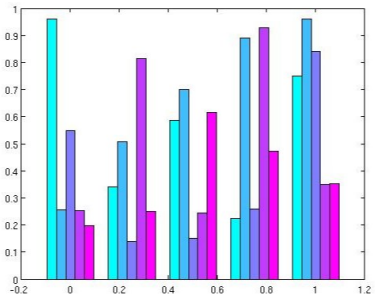
- Developed by The MathWorks
- First appeared in the late 1970s
- Short for ”Matrix Laboratory”
- All variables are matrices
- Several modules, e.g., ”Image processing toolbox”
- Cross-platform
- Can be slow or fast depending on application type

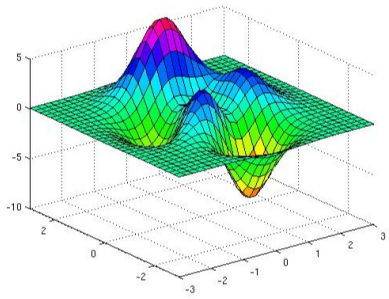
Matlab – Visualizations

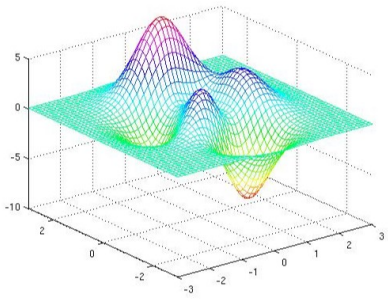
- Plot options

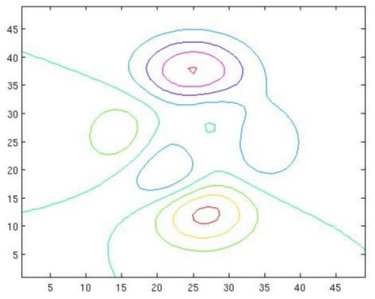


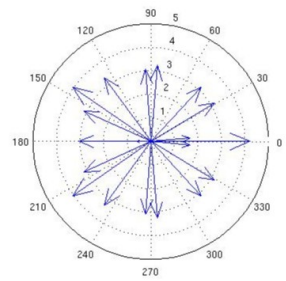












And many, many more...

Matlab – Visualizations

- Available plot-types depend on which toolboxes are installed.
- Huge amount of user written functions at Mathwork file exchange
- Easy to modify and/or create own visualization functions

Matlab – Import and Export

- Import and export of 'special' data very much dependent on user scripts
- Example: writeVTK.m

```
function [] = writeVTK(vol,vtkfile)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Usage: writeVTK(vol,vtkfile)
%
%   vol:     The 3D matrix to be saved to file
%   vtkfile: The output filename (string)
%
% Erik Vidholm 2005
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

Matlab – Import and Export

```
% dimensions
volinfo = whos('vol');

sz = volinfo.size;
X = sz(1); Y = sz(2); Z = 1;
if( length(sz) == 3 )
  Z = sz(3);
end

% open file
fid = fopen(vtkfile,'w');

% write header
fprintf(fid, '%s\n', '# vtk DataFile Version 3.0');
fprintf(fid, '%s\n', 'created by writeVTK (Matlab implementation by Erik Vidholm)');
fprintf(fid, '%s\n', 'BINARY');
fprintf(fid, '%s\n', 'DATASET STRUCTURED_POINTS');
fprintf(fid, '%s%d%c%d%c%d\n', 'DIMENSIONS ', X, ' ', Y, ' ', Z);
fprintf(fid, '%s%f%c%f%c%f\n', 'ORIGIN ', 0.0, ' ', 0.0, ' ', 0.0);
fprintf(fid, '%s%f%c%f%c%f\n', 'SPACING ', 1.0, ' ', 1.0, ' ', 1.0);
fprintf(fid, '%s%d\n', 'POINT_DATA ', X*Y*Z);

tp = volinfo.class;
if( strcmp(tp, 'uint8') > 0 )
  fprintf(fid, '%s\n', 'SCALARS image_data unsigned_char');
elseif( strcmp(tp, 'uint16') > 0 )
  fprintf(fid, '%s\n', 'SCALARS image_data unsigned_short');
elseif( strcmp(tp, 'uint32') > 0 )
  fprintf(fid, '%s\n', 'SCALARS image_data unsigned_int');
elseif( strcmp(tp, 'single') > 0 )
  fprintf(fid, '%s\n', 'SCALARS image_data float');
elseif( strcmp(tp, 'double') > 0 )
  fprintf(fid, '%s\n', 'SCALARS image_data double');
end

fprintf(fid, '%s\n', 'LOOKUP_TABLE default');

% write data as binary
fwrite(fid,vol,tp);

% close file
fclose(fid);
```

Matlab - Links

- www.mathworks.com
- www.mathworks.com/matlabcentral/fileexchange

Blender

- Free 3D modeling and animation software
- Features include
  - Physics and Particles
  - Liquid and softbody simulations
  - Game creation
  - Python support for scripting
  - Video sequencer
- Available for all common OS (installation file sized around 10-20 Mb)

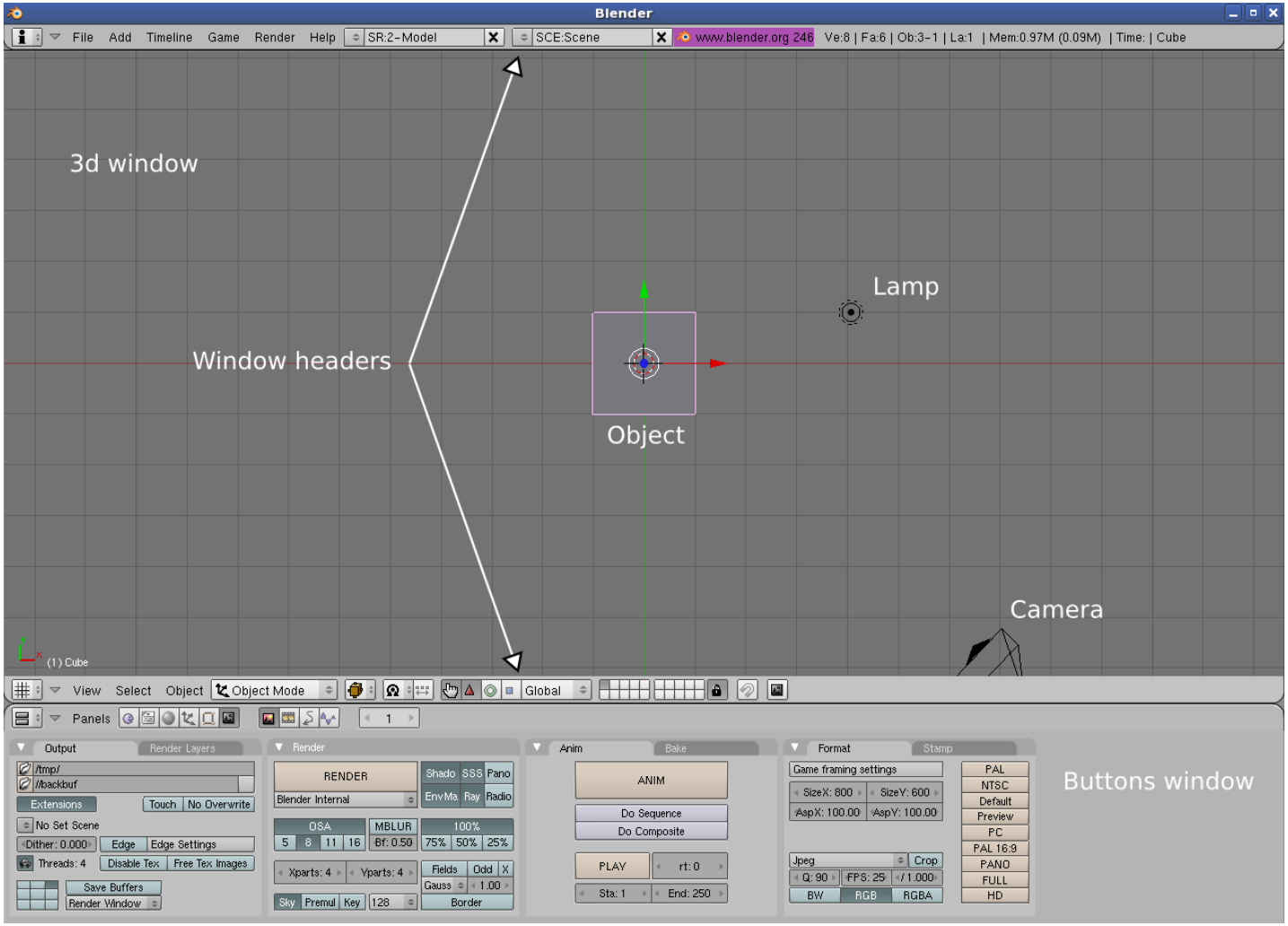
Blender – History

- Initially developed as an in-house application by the Dutch animation studio NeoGeo and Not a Number Technologies (NaN) during the late 90's
- NaN bankrupt 2002 (Blender v 2.25)
- Released under the GNU GPL for a one time payment of 100,000 Euros
- Blender is now managed by the Blender Foundation
- Version 2.5 is soon to be released

Blender

- Strengths:
  - Free (!!!)
  - Powerful
  - Interface for python scripting
  - Large user community -> tons of online material
- Weaknesses:
  - Confusing user interface (Under major reconstruction)
  - Sometimes hard to find good documentation

Blender – User interface



Blender – Getting around

- 'Middle mouse button' (MMB) – Rotate view
- 'Shift' + 'MMB' – Pan view
- 'Scroll wheel' – Zoom
- 'Ctrl' + 'MMB' – Zoom
- 'Numpad 1, 3, 7' – Front, right and top view
- 'Left mouse button' (LMB) – Move 3D cursor

Blender – Object selection

- Right mouse button (RMB) – Selects objects
- 'Shift' + RMB – Select multiple objects, deselect objects
- 'A' – Select all, clear selection
- 'B' – Box select
- 'B' + 'B' – Brush select (edit mode only)

Blender – Edit mode vs. Object mode

- 'TAB' key used to switch between modes for selected object
- In 'Object mode' the user can perform actions that affect the entire object (translation, scale, rotation,...)
- In 'Edit mode' local changes can be made by manipulating the vertices that the object consists of

Blender – Object manipulation

- 'G' – Grab (Move objects)
- 'R' – Rotate
- 'S' – Scale
- 'X' – Delete
- 'E' – Extrude (Edit mode)
- 'Z' – Shaded/Unshaded view
- 'Shift' + 'D' – Duplicate
- 'Ctrl' + 'Z' – Undo

Golden Rule
Always keep one hand on the keyboard!

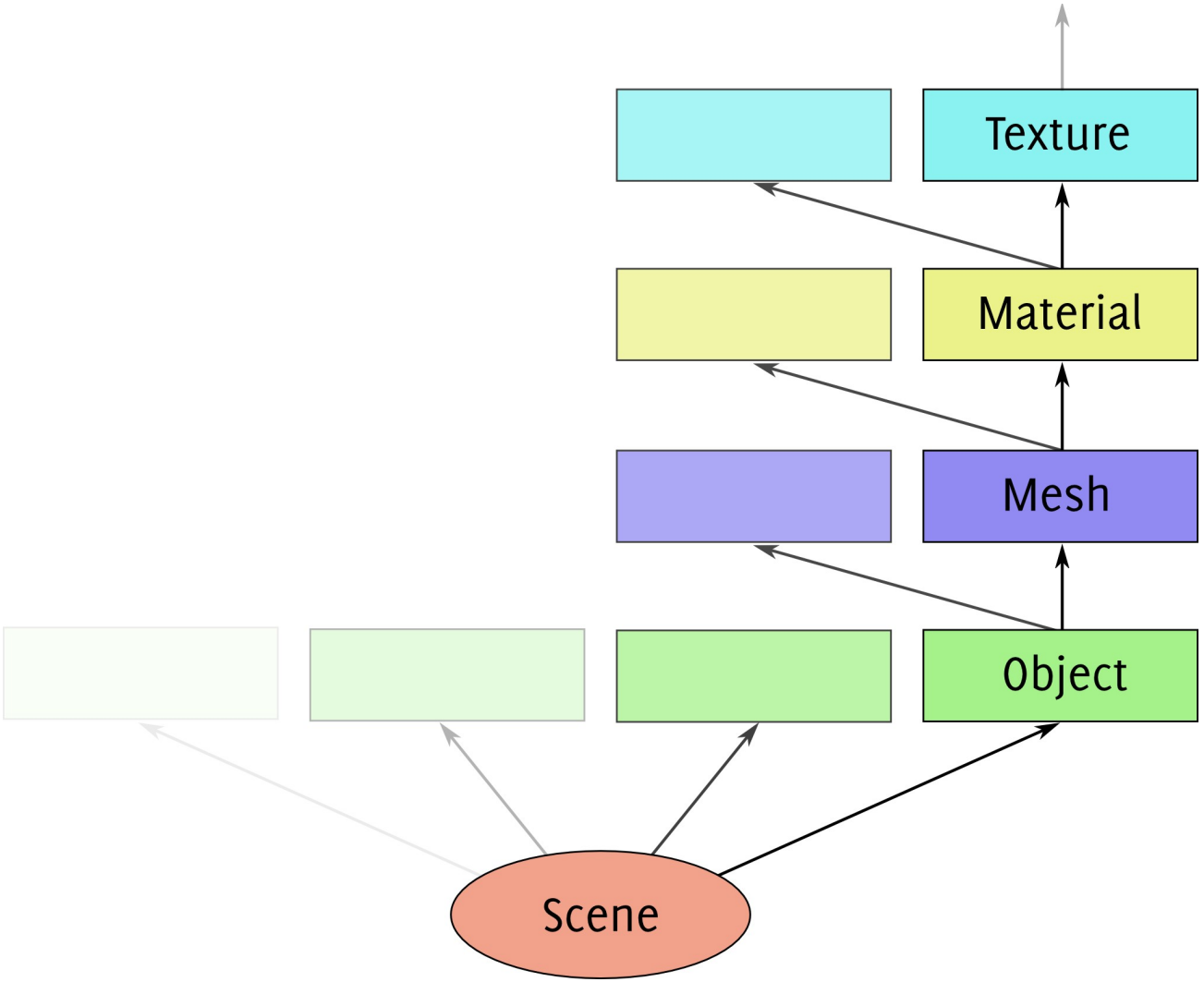
Blender – Rendering

- Numpad '0' – Shows the camera view
- 'F12' renders using current settings and camera, light positions
- Internal renderer supports ray-tracing
- Several external rendering engines supported (Yafray, Indigo)
- It is possible to make image composition (effects) in Blender based on the render layers

Blender – Loading and saving

- Save & Load .blend files
  - 'Ctrl' + 'w' – Open save file dialog
  - 'Ctrl' + 'o' – Open recent
  - 'F1' – Open load file dialog
- Save render result
  - 'F3' – Open save image dialog

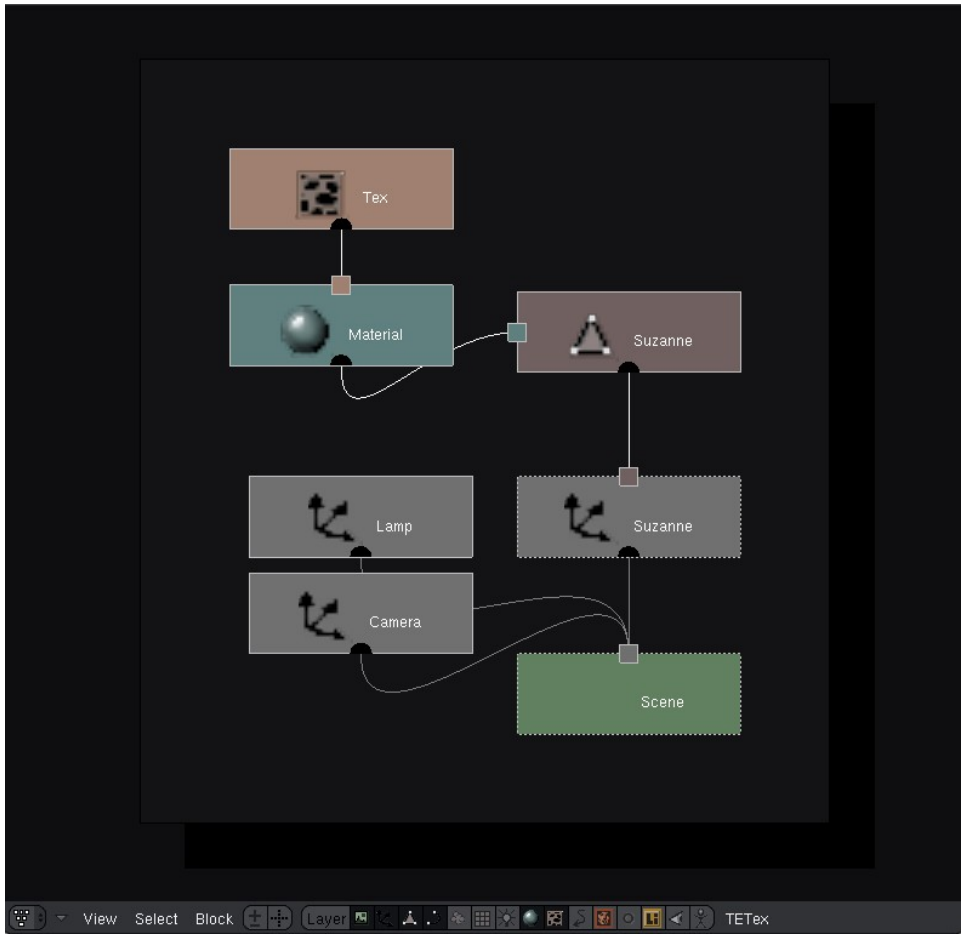
Blender – Object structure



Blender – Object structure

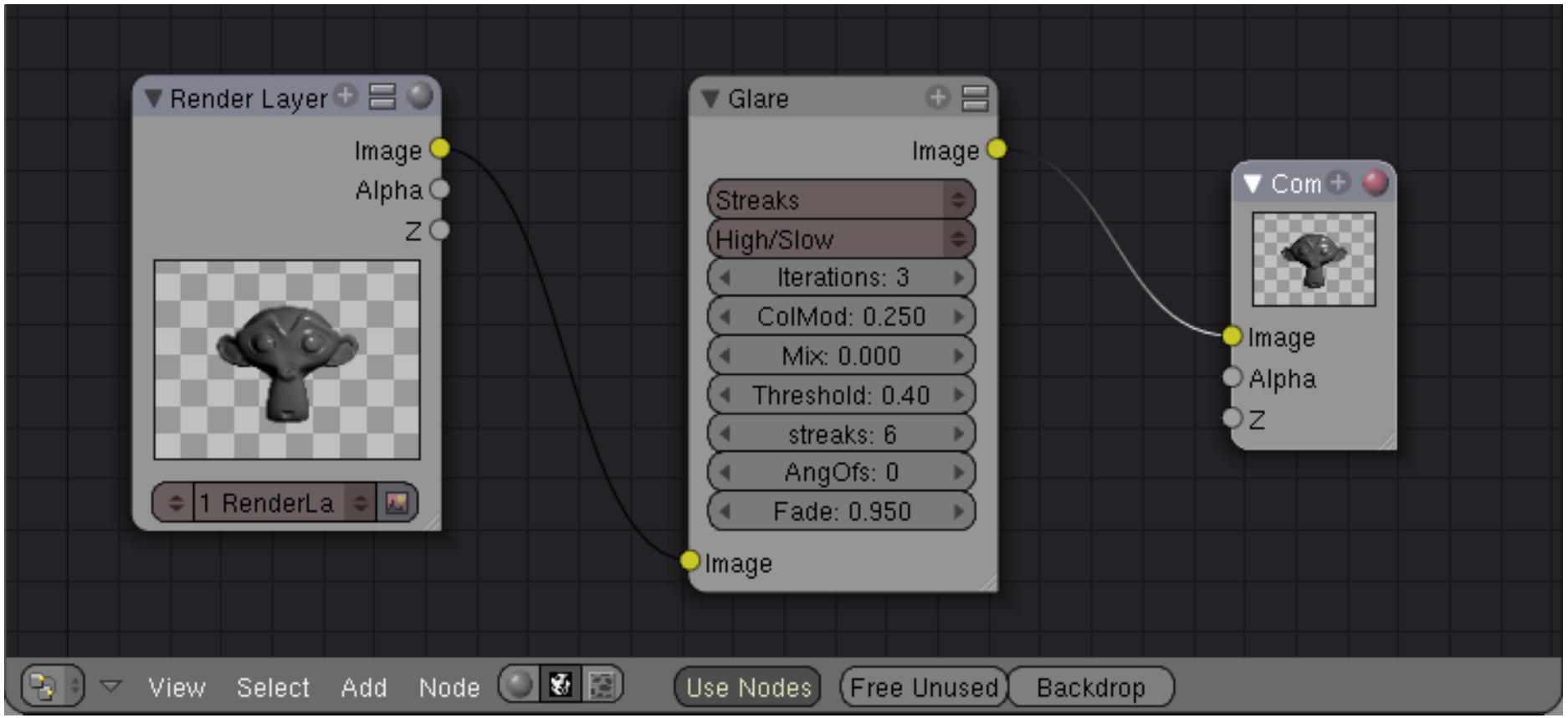
- Structure of a file can be seen using the OOPS-schematic view 

OOPS-schematic for a small scene



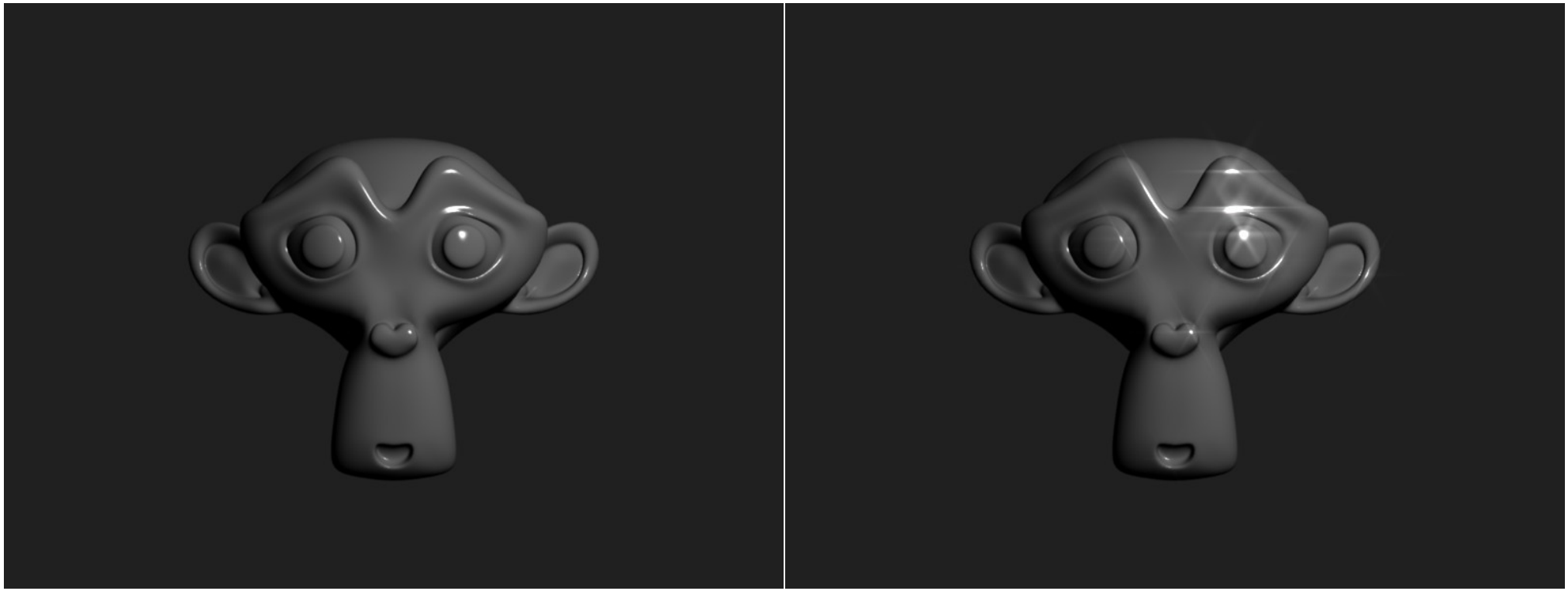
Blender – Node composition

- Built-in post-processing of your render



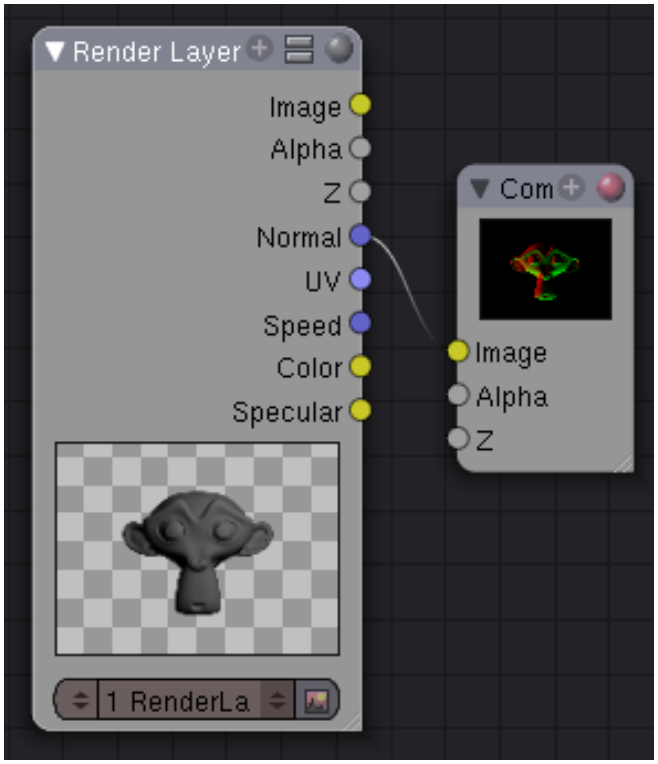
Blender – Node composition

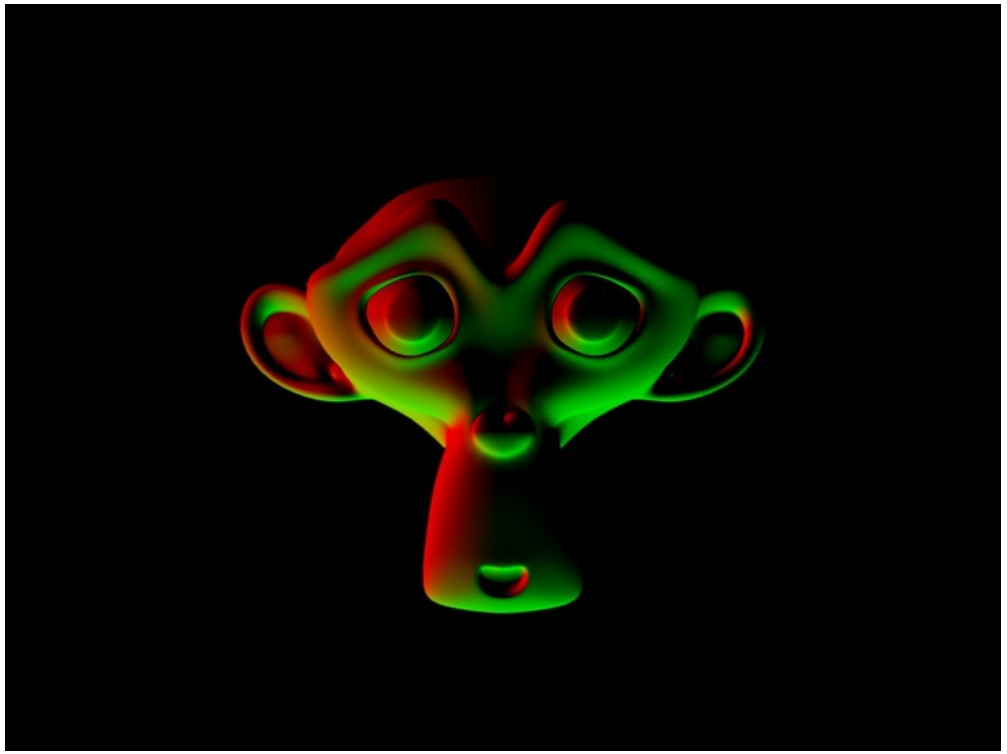
Effect of the 'Glare'-node



Blender – Node composition

- Possible to separate and manipulate different layers of the render result

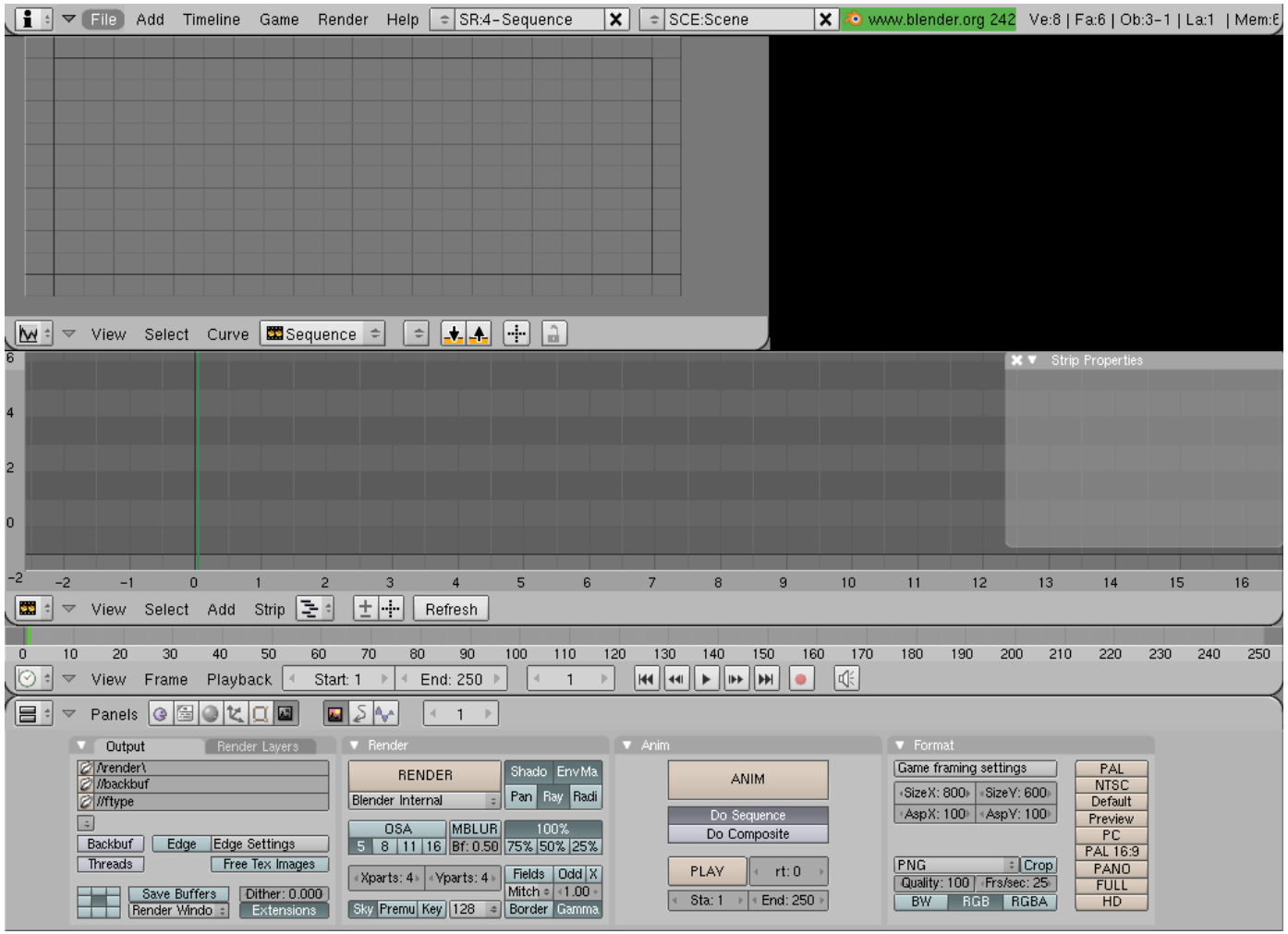




Blender – Sequence editor

- A very powerful tool for editing movies
- Can combine multiple video clips, sound and add effects to create a final result
- Can be used together with node editor to add more control

Blender – Sequence editor



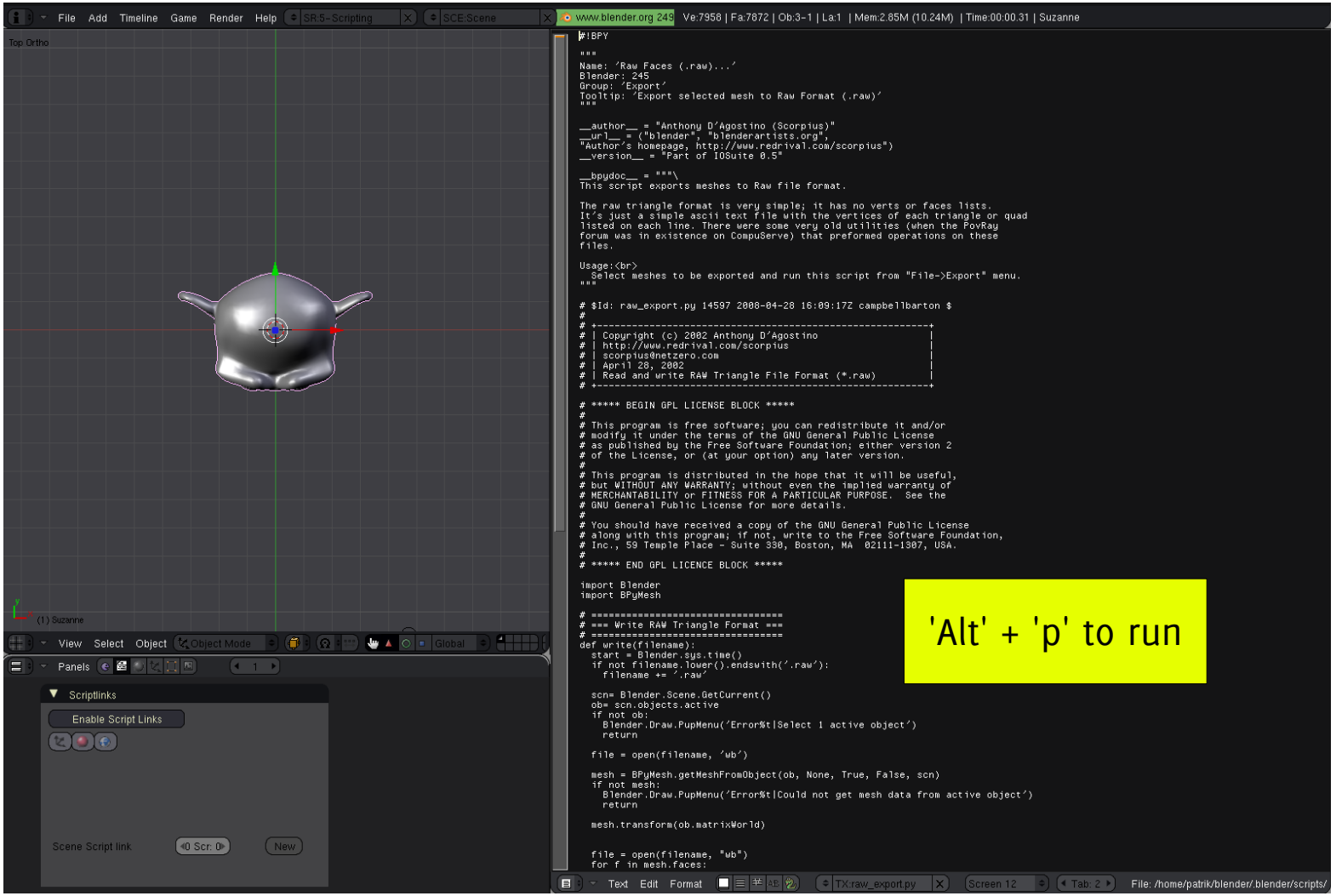
Blender – Import and Export

- Import/Export scripts exist for several common 3D-formats
- ”Open source quality”
- Writing custom scripts possible

Blender – Python scripting

- Blender has its own Python API
- Possible to control most of the functionality through Python scripts
- Learning threshold determined by ability to pick up Python

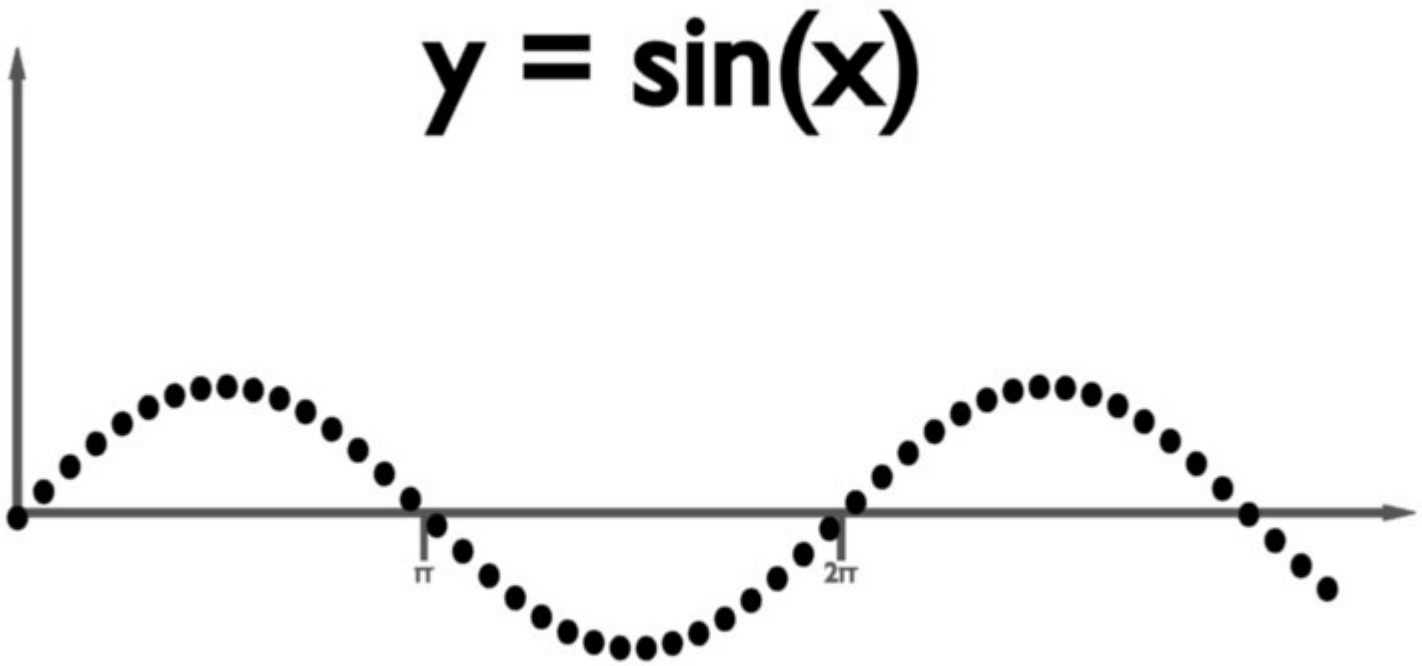
Blender – Python scripting



Blender – Import example

```
# Import Demo

import Blender
from Blender import *
import bpy

import math
from math import *

f=open("/home/patrik/pythondata.dat")

coords=[]
edges=[]
counter = 0

for l in f:
       l=l.split(',')
       d=[float(l[0]),float(l[1]),float(l[2])]
       coords.append(d)

       counter = counter + 1
       print(counter)
       if counter > 1:
              edges.append([counter-2,counter-1])

       me = Mesh.Primitives.UVsphere(6,6,0.2) # create a primitive

       sc = Scene.GetCurrent()          # get current scene
       ob2 = sc.objects.new(me)         # add a new mesh-type object to the scene
       ob2.setLocation(d)


me = bpy.data.meshes.new()              # create empty mesh
me.verts.extend(coords)                 # populate with vertices
me.edges.extend(edges)                  # create edges
scn = bpy.data.scenes.active            # link object to current scene
ob = scn.objects.new(me)

Blender.Redraw()
```

Blender – Import example



Blender – SCIENTIFIC visualizations

- Blender is used at scientific groups over the world
- Free and open source but still powerful the main selling points
- Uses include
  - Electron microscope data visualizations (http://www.sciencemag.org/content/vol320/issue5872/cover.dtl)
  - Population behavior simulation using the Blender game engine (http://vimeo.com/2158835)
  - Molecular visualization and simulation (http://www.scivis.ifc.cnr.it/)

Blender – Some links

- A few links that could be interesting
  - www.blender.org
  - www.blendernation.com
  - www.blendercookie.com
  - www.blenderartists.org
  - www.elephantsdream.org
  - www.bigbuckbunny.org
  - www.open3dcourse.se (Gävle högskola summer course)