Design Tools for Satellite Models

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Mission Technologies

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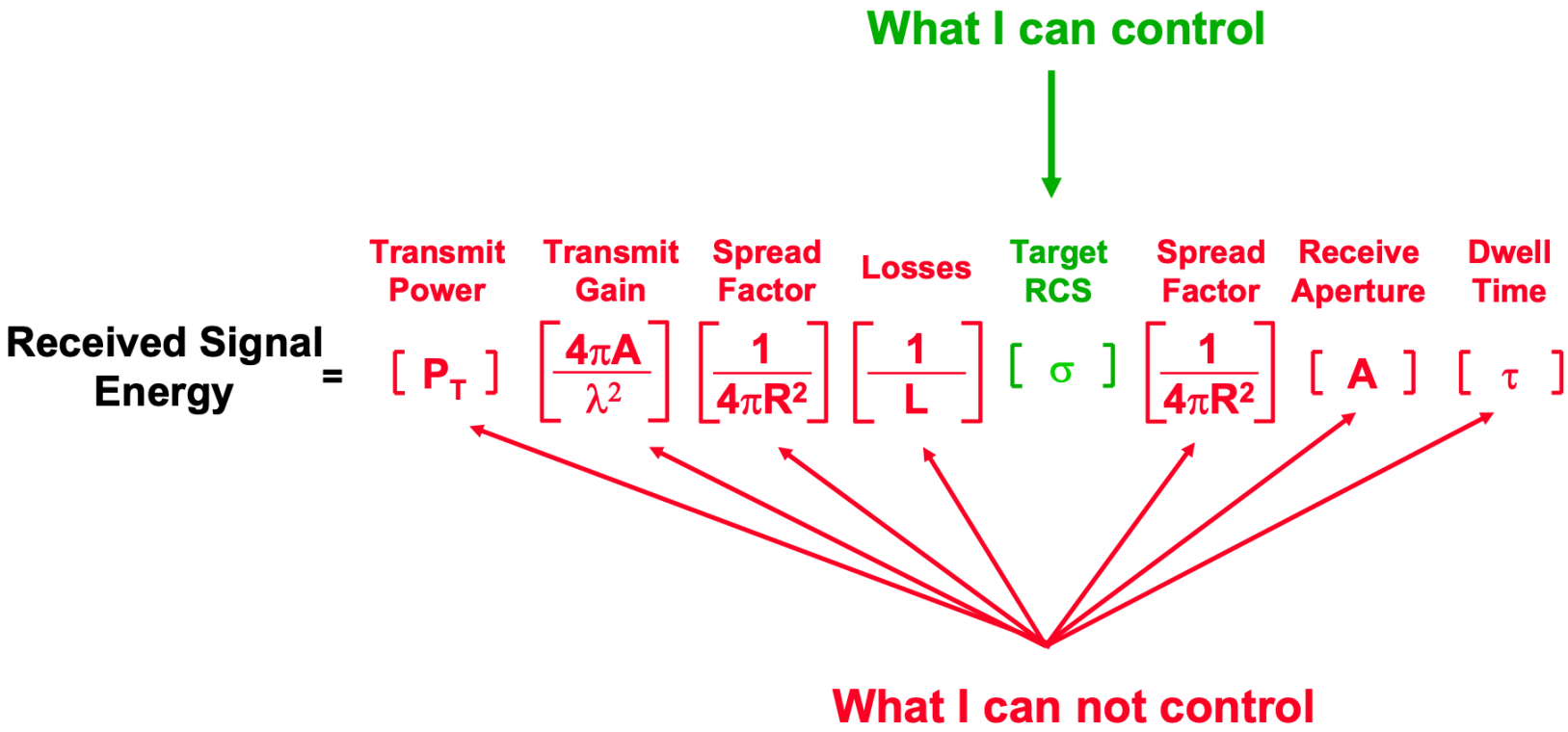
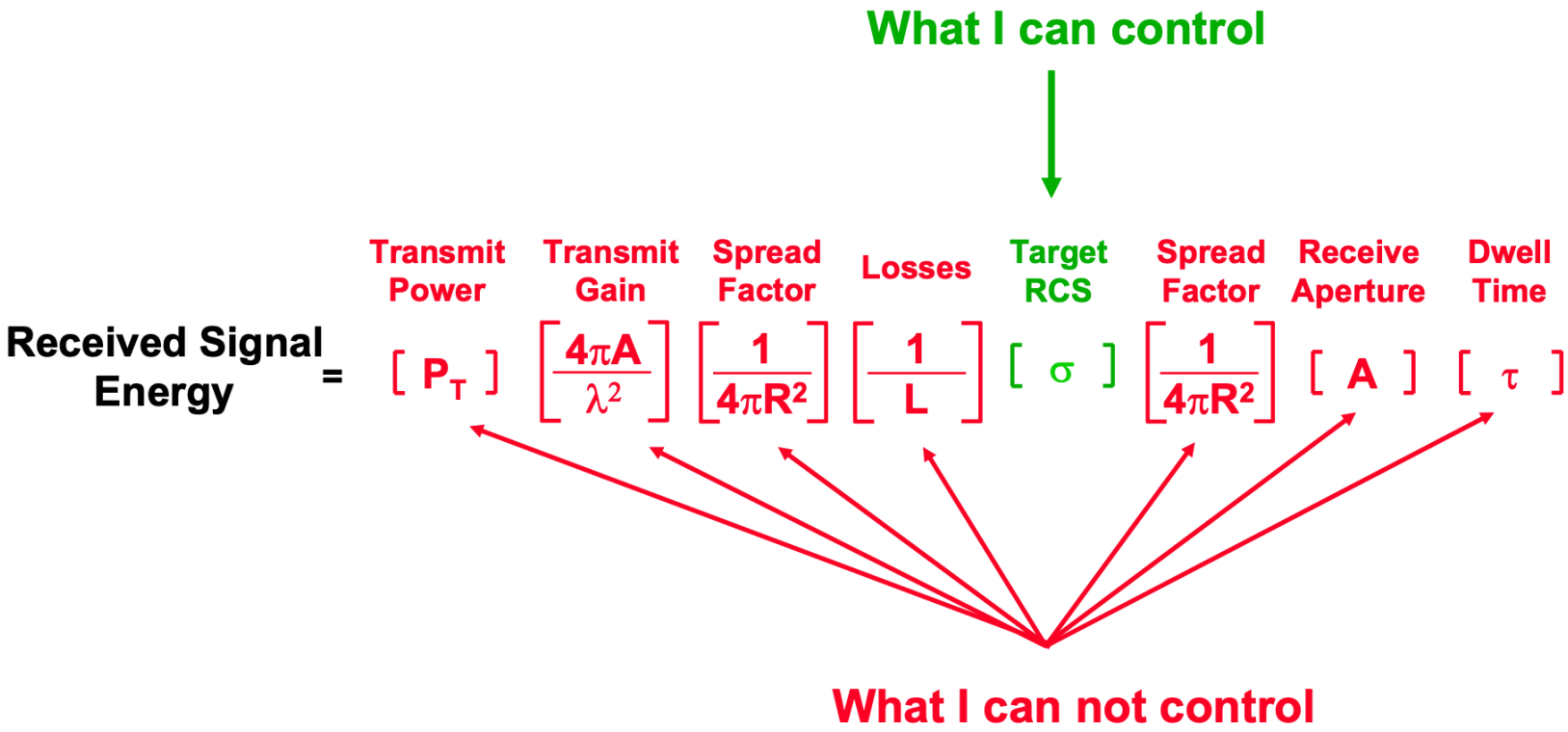
Overview

Control Factors



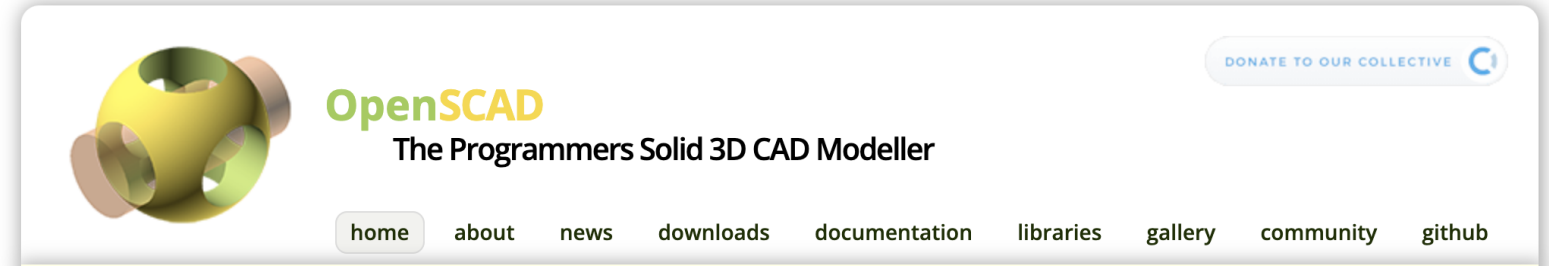
Lab 2002

Control Factors

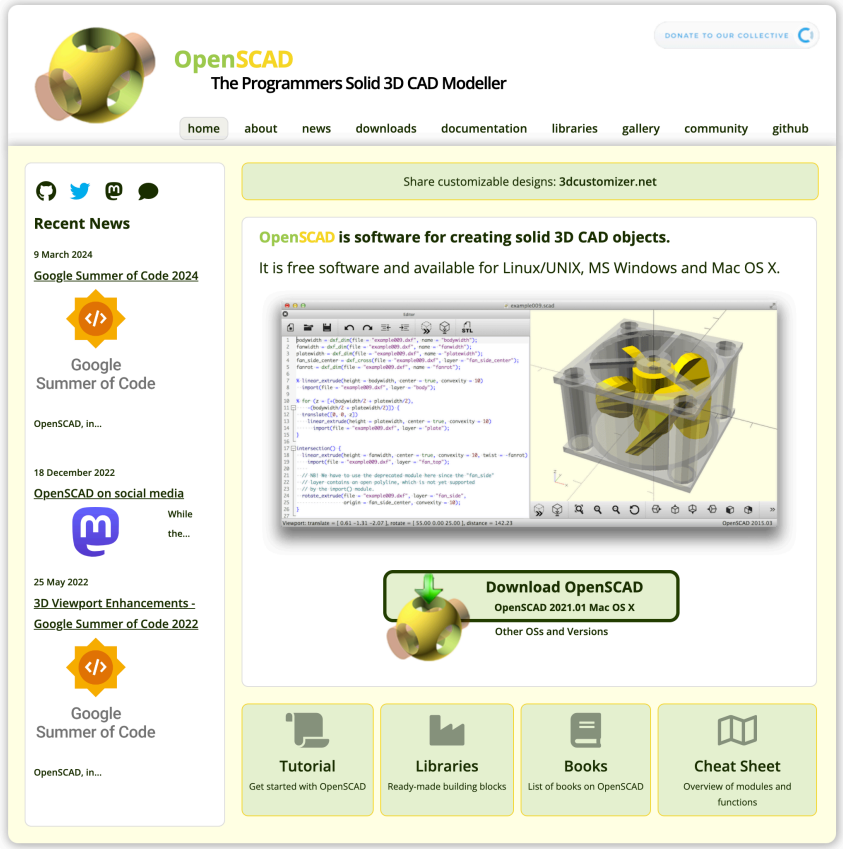


Lab 2002

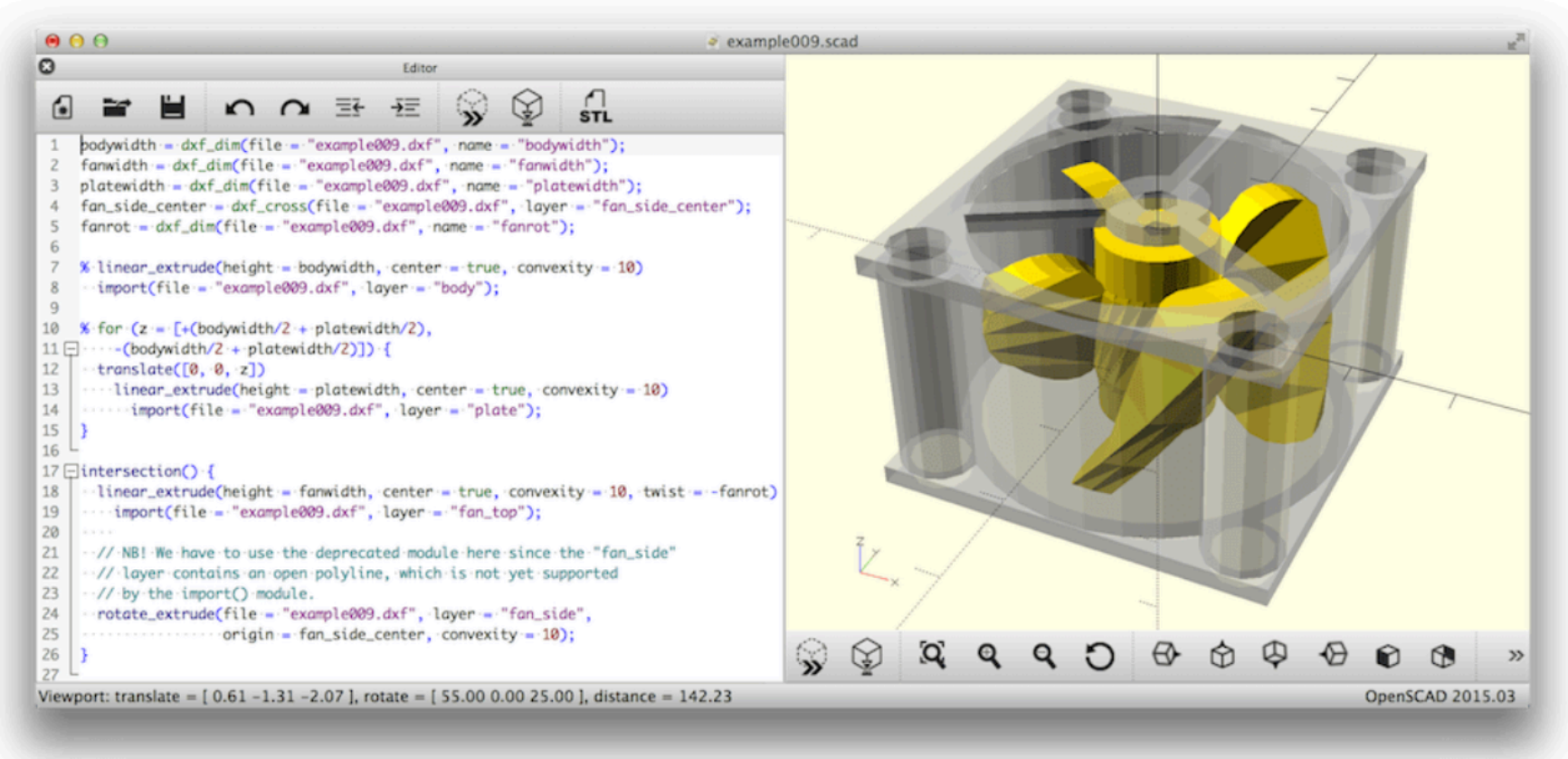
The Programmers Solid 3D CAD Modeller



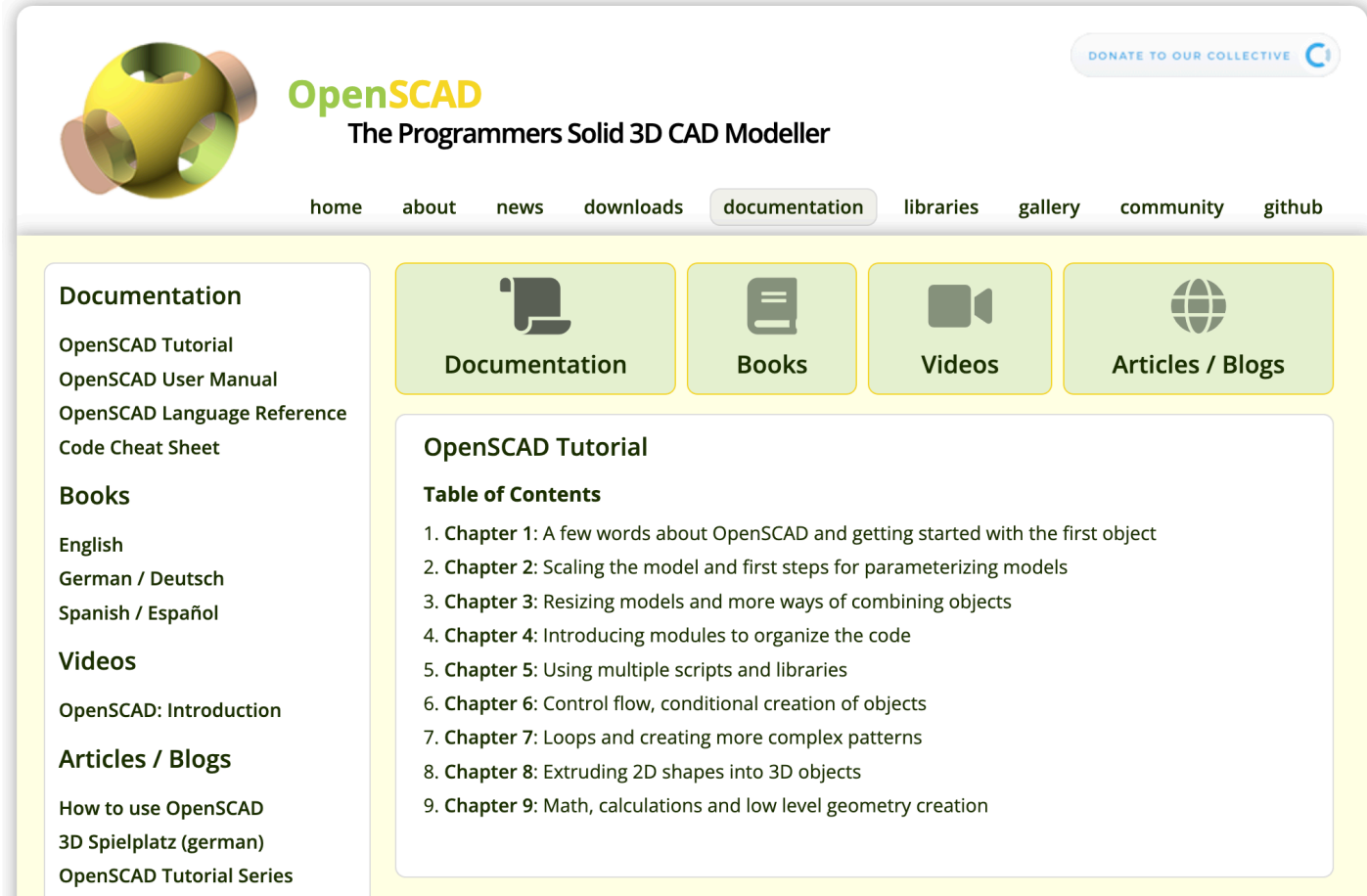
The Programmers Solid 3D CAD Modeller



OpenSCAD is Pythonic



OpenSCAD Tutorials



OpenSCAD Libraries

OpenSCAD Book

OpenSCAD Cheat Sheet

OpenSCAD v2021.01

Syntax

```
var = value;
var = cond ? value_if_true : value_if_false;
var = function (x) x + x;
module name(…) { … }
name();
function name(…) = …
name();
include <….scad>
use <….scad>
```

Constants

undef	undefined value
PI	mathematical constant π (~3.14159)

Operators

n + m	Addition
n - m	Subtraction
n * m	Multiplication
n / m	Division
n % m	Modulo
n ^ m	Exponentiation
n < m	Less Than
n <= m	Less or Equal
b == c	Equal
b != c	Not Equal
n >= m	Greater or Equal
n > m	Greater Than
b && c	Logical And
b || c	Logical Or
!b	Negation

Special variables

$fa	minimum angle
$fs	minimum size
$fn	number of fragments
$t	animation step
$vpr	viewport rotation angles in degrees
$vpt	viewport translation
$vpd	viewport camera distance
$vpf	viewport camera field of view
$children	number of module children
$preview	true in F5 preview, false for F6

Modifier Characters

*	disable
!	show only
#	highlight / debug
%	transparent / background

2D

```
circle(radius | d=diameter)
square(size,center)
square([width,height],center)
polygon([points])
polygon([points],[paths])
text(t, size, font,
     halign, valign, spacing,
     direction, language, script)
import("….ext", convexity)
projection(cut)
```

3D

```
sphere(radius | d=diameter)
cube(size, center)
cube([width,depth,height], center)
cylinder(h,r|d,center)
cylinder(h,r1|d1,r2|d2,center)
polyhedron(points, faces, convexity)
import("….ext", convexity)
linear_extrude(height,center,convexity,twist,slices)
rotate_extrude(angle,convexity)
surface(file = "….ext",center,convexity)
```

Transformations

```
translate([x,y,z])
rotate([x,y,z])
rotate(a, [x,y,z])
scale([x,y,z])
resize([x,y,z],auto,convexity)
mirror([x,y,z])
multmatrix(m)
color("colorname",alpha)
color("#hexvalue")
color([r,g,b,a])
offset(r|delta,chamfer)
hull()
minkowski(convexity)
```

Lists

```
list = […,…,…];  create a list
var = list[2];  index a list (from 0)
var = list.z;  dot notation indexing (x/y/z)
```

Boolean operations

```
union()
difference()
intersection()
```

List Comprehensions

```
Generate [ for (i = range|list) i ]
Generate [ for (init;condition;next) i ]
Flatten [ each i ]
Conditions [ for (i = …) if (condition(i)) i ]
Conditions [ for (i = …) if (condition(i)) x else y ]
Assignments [ for (i = …) let (assignments) a ]
```

Flow Control

```
for (i = [start:end]) { … }
for (i = [start:step:end]) { … }
for (i = […,…,…]) { … }
for (i = …, j = …, …) { … }
intersection_for(i = [start:end]) { … }
intersection_for(i = [start:step:end]) { … }
intersection_for(i = […,…,…]) { … }
if (…) { … }
let (…) { … }
```

Type test functions

```
is_undef
is_bool
is_num
is_string
is_list
is_function
```

Other

```
echo(…)
render(convexity)
children([idx])
assert(condition, message)
assign (…) { … }
```

Functions

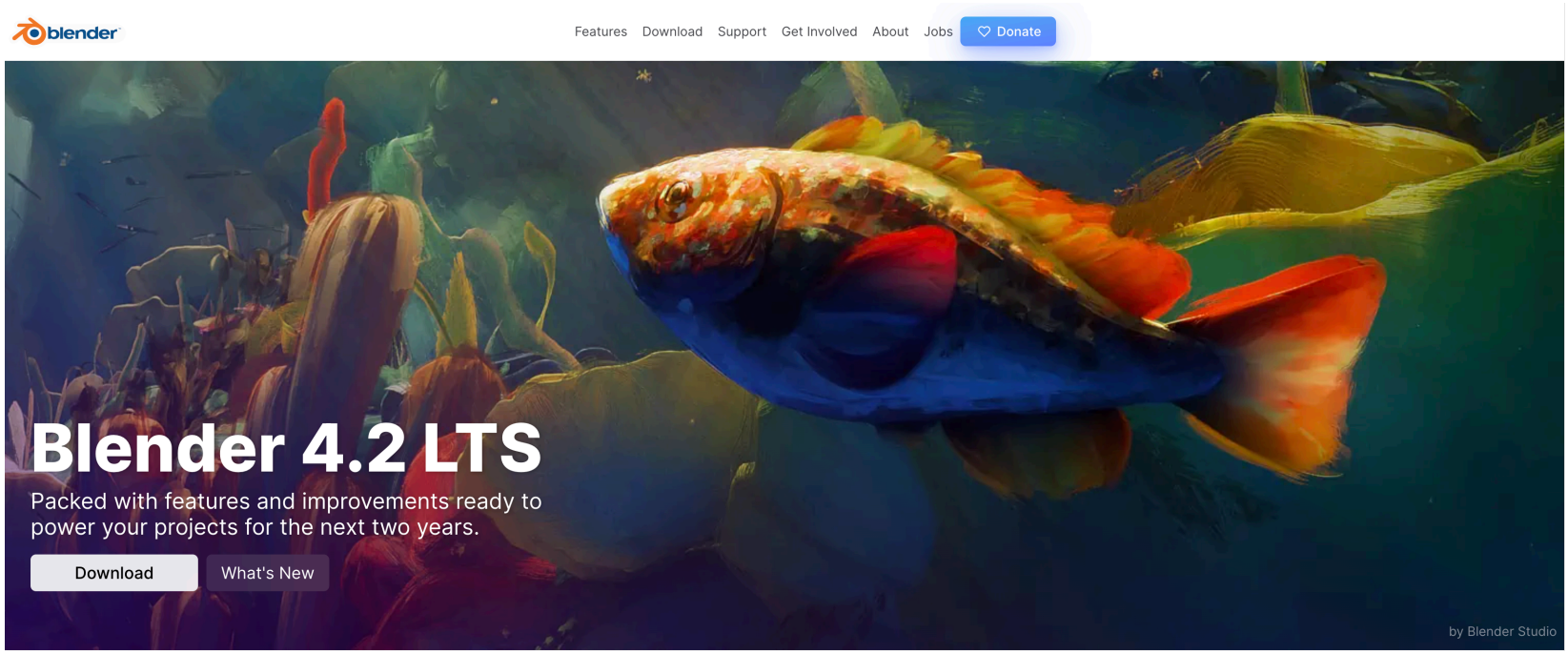
```
concat
lookup
str
chr
ord
search
version
version_num
parent_module(idx)
```

Mathematical

```
abs
sign
sin
cos
tan
acos
asin
atan
atan2
floor
round
ceil
ln
len
let
log
pow
sqrt
exp
rands
min
max
norm
cross
```

Links: Official website | Code | Issues | Manual | MCAD library | Mailing list | Other links

Sample Texts



User Manual **Developer Documentation** **Python API**

Primitives

Primitives

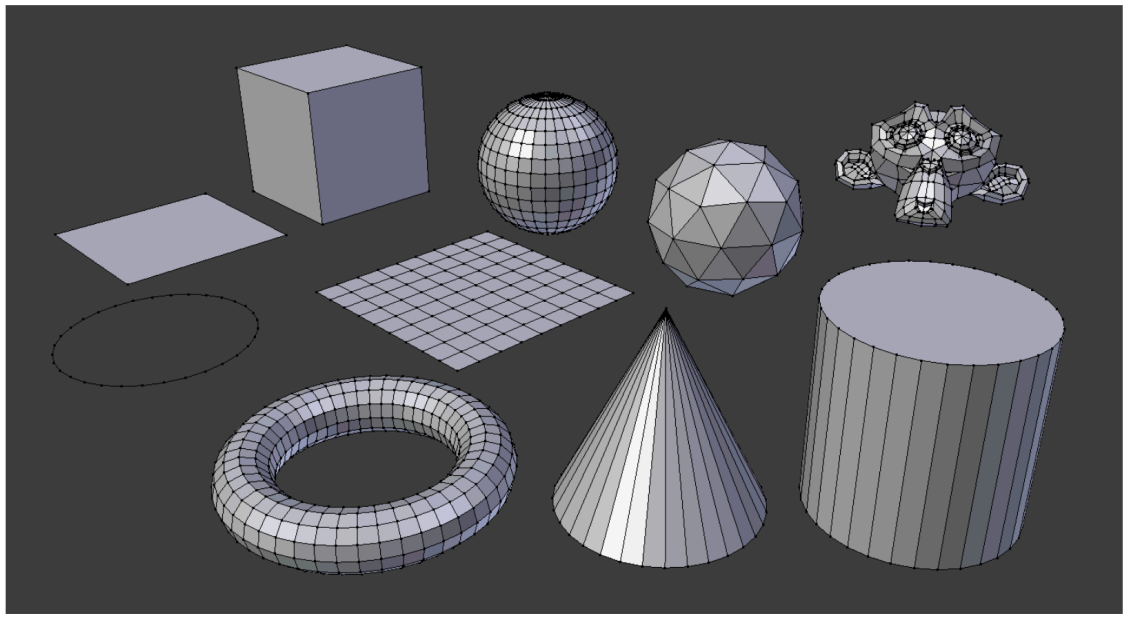
Reference

Mode: Object Mode and Edit Mode

Menu: Add ▸ Mesh

Shortcut: Shift−A

A common object type used in a 3D scene is a mesh. Blender comes with a number of "primitive" mesh shapes that you can start modeling from. You can also add primitives in Edit Mode at the 3D cursor.



Blender's standard primitives.

Stereolithography File Format

STL

Reference

Category: Import-Export
Menu: File ▸ Import/Export ▸ Stl (.stl)

The STL-file format is useful if you intend to import/export the files for CAD software. It is also commonly used for loading into 3D printing software.

Importing

General

Scale
Value by which to scale the imported objects in relation to the world's origin.

Scene Unit
Apply current scene's unit (as defined by unit scale) to imported data.

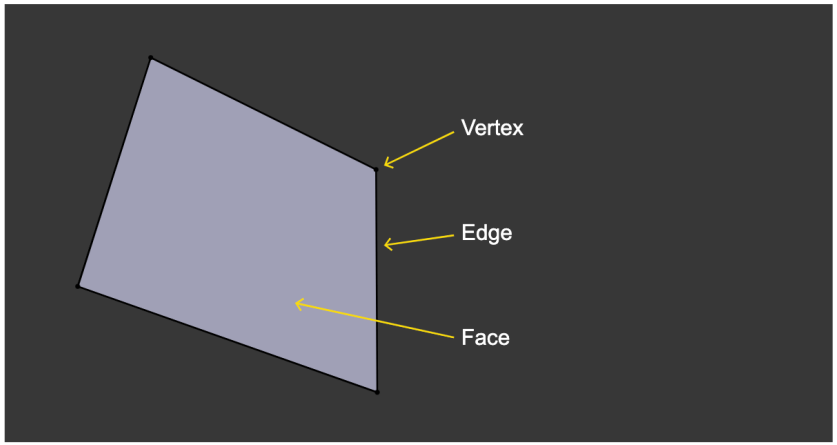
Forward / Up Axis
Since many applications use a different axis for pointing upwards, these are axis conversion for these settings, Forward and up axes – By mapping these to different axes you can convert rotations between applications default up and forward axes.

Blender uses Y forward, Z up (since the front view looks along the +Y direction). For example, it is common for applications to use Y as the up axis, in that case -Z forward, Y up is needed.

Mesh Basics

Structure

With meshes, everything is built from three basic structures: *vertices*, *edges* and *faces*.



Example of mesh structure. #

Normals

Editing Custom Split Normals

Reference

Mode: Edit Mode
Menu: Mesh ▸ Normals
Shortcut: Alt-N

There are a number of tools for editing custom split normals. The custom normal mesh edit tools can affect all normals (the default), or only selected ones. To select a custom normal associated with a particular vertex and face:

- Make the element selection mode both Vertex and Face (use Shift-LMB to enable the second one).
- Select one or more vertices, then select a face. This can be repeated to select more vertices and a different face and so on. It is easiest to see the effect of these tools if you turn on the Edit Mode Overlays option *Display vertex-per-face normals as lines*.

See also

Editing Normals.

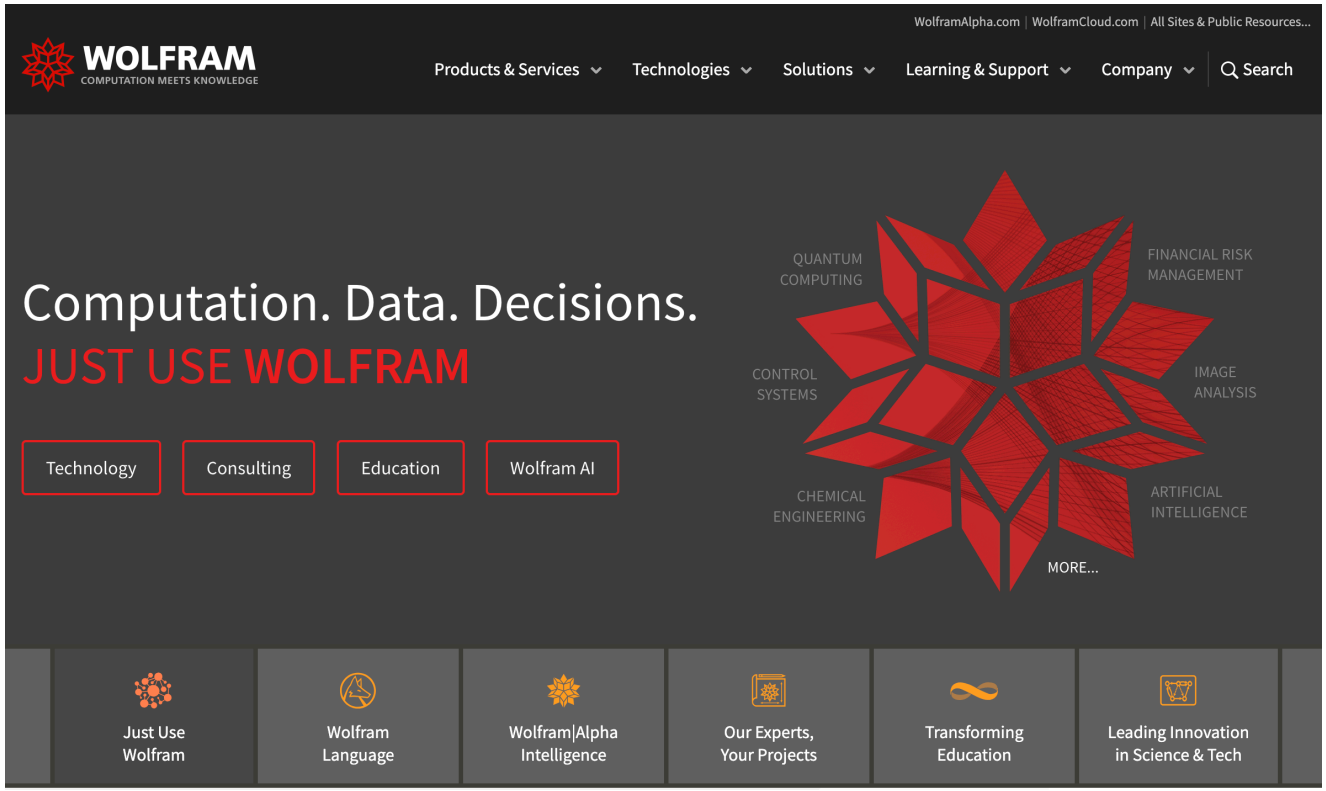
Importing Custom Split Normals

Some tools, particularly those used in CAD, tend to generate irregular geometry when tessellating their objects into meshes (very thin and long triangles, etc.). Auto-computed normals on such geometry often gives bad artifacts, so it is important to be able to import and use the normals as generated by the CAD tool itself.

Note

Currently, only the FBX Importer and Alembic Importer are capable of importing custom normals.

Wolfram - née Mathematica



C-3PO of Information Interchange

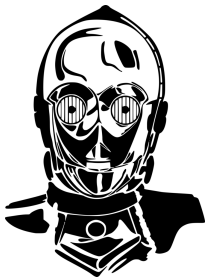
GUIDE

Listing of All Formats

The Wolfram Language supports many formats, with many subformats, variants, and options.

"3DS" — 3D Studio format (.3ds)
"7z" — 7z compression and archival format (.7z)

"ACO" — Adobe color palette format (.aco)
"Affymetrix" — Affymetrix microarray formats (.cel, .cdf, .chp, .gin, .psi)
"AgilentMicroarray" — Agilent microarray data format (.txt)
"AIFF" — AIFF Macintosh sound format (.aif, .aiff)
"ApacheLog" — Apache access log file format
"ArcGRID" — ESRI GIS format
"AU" — μ law encoding Unix Audio Format (.au)
"AVI" — Microsoft AVI format (.avi)



"Base64" — Base64 ASCII encoding
"BDF" — BDF physiological signal recordings format (.bdf)
"Binary" — sequence of binary data types
"Bit" — sequence of binary bits
"BMP" — Microsoft bitmap format (.bmp)
"BSON" — JSON-like binary format (.bson)
"Byte" — sequence of 8-bit unsigned integers
"BYU" — BYU 3D geometry format (.byu)
"BZIP2" — bzip2 compression format (.bz2)

"C" — C code generation (.c)
"CDED" — Canadian digital elevation data (.dem)
"CDF" — Wolfram Computable Document Format (.cdf)
"CDX" — ChemDraw Exchange format (.cdx)
"CDXML" — ChemDraw Exchange XML format (.cdxml)
"Character8" — sequence of 8-bit characters
"Character16" — sequence of 16-bit Unicode characters
"CIF" — CIF molecular model format (.cif)
"CML" — Chemical Markup Language (.cml)
"Complex64" — IEEE single-precision complex numbers
"Complex128" — IEEE double-precision complex numbers
"Complex256" — IEEE quad-precision complex numbers
"CSV" — comma-separated values (.csv)
"Cube" — Gaussian Cube file (.cub)
"CUR" — Windows cursor resource format (.cur)

"DAE" — COLLADA digital asset exchange format (.dae)
"DBF" — dBase database file (.dbf)
"DICOM" — DICOM medical image format (.dcm, .dic)
"DICOMDIR" — directory of DICOM files (DICOMDIR)
"DIF" — VisiCalc data interchange format (.dif)
"DIMACS" — DIMACS graph data format (.col, .col.b)
"Directory" — filesystem directory hierarchy
"DOCX" — Microsoft Word format import
"DOT" — DOT graph data format (.gv, .dot)
"DTA" — Stata database transport format (.dta)
"DXF" — AutoCAD 2D and 3D format (.dxf)

"EDF" — EDF physiological signal recordings format (.edf)
"EML" — mail message format
"EPS" — Encapsulated PostScript (.eps)
"ExpressionJSON" — JSON for representing expressions (.json)
"ExpressionML" — Wolfram Language expression XML format (.xml)

"FASTA" — bioinformatics sequence format (.fasta, .fa, .fsa, .mpfa)
"FASTQ" — FASTQ molecular biology format (.fastq, .fq)
"FCHK" — Formatted Checkpoint file (.fchk)
"FCS" — FCS molecular biology format (.fcs, .lmd)
"FITS" — FITS astronomical data and image format (.fit, .fits)
"FLAC" — FLAC lossless audio codec (.flac)
"FLV" — Adobe/Macromedia Flash video format (.flv)
"FMU" — FMI model and simulation exchange format (.fmu)

C-3PO of Information Interchange II

"GaussianLog" — Gaussian log file (.log)
"GenBank" — GenBank molecular biology format (.gb, .gbk)
"GeoJSON" — geographic data format based on JSON (.geojson)
"GeoTIFF" — annotated TIFF raster files (.tif)
"GIF" — static or animated GIF (.gif)
"GPX" — GPX global positioning data format (.gpx)
"Graph6" — dense graph format (.g6)
"Graphlet" — GML graph data (.gml)
"GraphML" — GraphML graph format (.graphml)
"GRIB" — GRIB scientific data format (.grb, .grib)
"GTOPO30" — USGS global topographic data (.dem)
"GXL" — GXL graph data (.gxl)
"GZIP" — Unix GZIP compression (.gz)

"HarwellBoeing" — Harwell–Boeing sparse matrix format
"HDF" — NCSA hierarchical data format (.hdf)
"HDF5" — NCSA HDF 5 hierarchical data format (.h5)
"HEIF" — High Efficiency Image Format (.heic, .heif)
"HIN" — HyperChen HIN data format (.hin)
"HTML" — HTML format (.htm, .html), including embedded GIFs, CSS, etc.
"HTMLFragment" — HTML fragment (.htm, .html)
"HTTPRequest" — HTTP request as transmitted to a web server
"HTTPResponse" — HTTP response as generated by a web server

"ICC" — ICC color profile format (.icc, .icm)
"ICO" — Windows icon resource format (.ico)
"ICS" — iCalendar format (.ics, .ical, .ifb)
"ICNS" — Macintosh icons format (.icns)
"Ini" — key-value configuration format (.ini)
"Integer8" — sequence of 8-bit signed integers
"Integer16" — sequence of 16-bit signed integers
"Integer24" — sequence of 24-bit signed integers
"Integer32" — sequence of 32-bit signed integers
"Integer64" — sequence of 64-bit signed integers
"Integer128" — sequence of 128-bit signed integers
"ISO" — ISO archival format (.iso)

"JavaProperties" — Java key-value format (.properties)
"JavaScriptExpression" — JSON with objects as associations (.json)
"JCAMP-DX" — chemical spectroscopy format (.jdx, .dx, .jcm)
"JPEG" — JPEG raster image format (.jpeg, .jpg)
"JPEG2000" — JPEG 2000/JP2 raster image format (.jp2, .j2k)
"JVX" — JavaView format (.jvx)
"JSON" — JSON web service description (.json)

"KML" — Google Earth GIS format (.kml, .kmz)

"LaTeX" — LaTeX format (.latex)
"LEDA" — LEDA graph data format (.gw, .lgr)
"List" — numbers or strings, one per line
"LWO" — LightWave 3D file format (.lwo)

"MAT" — MATLAB/Octave data format (.mat)
"MathML" — MathML math content format
"Matroska" — Matroska multimedia container format (.mkv)
"Maya" — Maya entity files (.ma)
"MBOX" — MBOX Unix mailbox format (.mbox)
"MCTT" — Modelica "CombiTimeTable" data format (.txt)
"MDB" — Microsoft Access database file (.mdb)
"MGF" — Wolfram Mathematica MGF bitmap format (.mgf)
"MIDI" — MIDI music format (.mid)
"MMCIF" — MMCIF 3D molecular model format (.cif)
"MO" — Modelica model format (.mo)
"MOBI" — Mobipocket ebook format import
"MOL" — MDL MOL molecular models and drawings format (.mol)
"MOL2" — Tripos MOL2 format (.mol2)
"MP3" — MP3 audio format (.mp3)
"MP4" — MPEG-4 Part 14 video format (.mp4)
"MPS" — MPS linear programming system format (.mps)
"MTP" — Minitab portable worksheet format (.mtp)
"MTX" — Matrix Market sparse matrix format (.mtx)
"MX" — Wolfram Language serialized package format (.mx)
"MXNet" — MXNet net representation format (.json, .params)

C-3PO of Information Interchange III

"NASACDF" — NASA common data format (.cdf)
"NB" — Wolfram Notebook format (.nb)
"NDK" — NDK seismographic data format (.ndk)
"NetCDF" — Unidata scientific data format
"NEXUS" — NEXUS phylogenetic format (.nex, .nxs)
"NOFF" — 3D object file format with normals (.noff, .cnoff)

"OBJ" — Wavefront OBJ format (.obj)
"ODS" — OpenDocument spreadsheet format (.ods)
"OFF" — 3D object file format (.off, .coff)
"Ogg" — Ogg multimedia container format (.ogg)
"OpenEXR" — OpenEXR raster image format (.exr)

"Pajek" — Pajek graph data format (.net)
"PBM" — ASCII portable bitmap format (.pbm)
"PCAP" — Network packet capture format (.pcap)
"PCX" — Windows Paintbrush format (.pcx)
"PDB" — Protein Data Bank format (.pdb)
"PDF" — Adobe Acrobat PDF format (.pdf)
"PGM" — ASCII portable graymap format (.pgm)
"PHPIni" — PHP-enabled configuration format (.ini)
"PLY" — PLY 3D geometry format (.ply)
"PNG" — PNG raster image format (.png)
"PNM" — ASCII portable raster format (.pnm)
"POV" — POV-Ray ray-tracing object description format (.pov)
"PPM" — ASCII portable color pixmap format (.ppm)
"PXR" — Pixar raster format (.pxr)
"PythonExpression" — Python data format (.py)

"QuickTime" — Apple QuickTime multimedia container format (.mov)

"RAR" — RAR compression and archival format (.rar)
"Raw" — raw image format
"RawBitmap" — pure binary bitmap data
"RawJSON" — JSON with objects as associations (.json)
"RData" — R data format family import
"RDS" — R data format family import
"Real32" — IEEE single-precision real numbers
"Real64" — IEEE double-precision real numbers
"Real128" — IEEE quad-precision real numbers
"RIB" — Renderman interchange format (.rib)
"RLE" — run-length encoding (.rle)
"RSS" — RSS feed format (.rss)
"RTF" — Microsoft Rich Text Format (.rtf)

"SAS7BDAT" — SAS database transport format (.sas7bdat)
"SAV" — SPSS database transport format (.sav, .zsav)
"SCT" — Scitex CT prepress format (.sct)
"SDF" — MDL SDF format (.sdf)
"SDTS" — SDTS DLG and DEM spatial data files
"SDTSDEM" — digital elevation files
"SFF" — SFF molecular biology format (.sff)
"SHP" — ESRI shape file format (.shp)
"SMA" — SystemModeler model archive format (.sma)
"SME" — SystemModeler experiment format (.sme)
"SMILES" — SMILES chemical format (.smi)
"SND" — SND file format (.snd)
"SP3" — geospatial data format (.sp3)
"Sparse6" — sparse graph format (.s6)
"STL" — stereolithography format (.stl)
"String" — arbitrary data as a Wolfram Language string
"SVG" — Scalable Vector Graphics format (.svg)
"SurferGrid" — geospatial data format (.grd)
"SXC" — OpenOffice 1.0 spreadsheet file (.sxc)

C-3PO of Information Interchange IV

"Table" — arbitrary tabular data (.dat)
"TAR" — Unix TAR archive (.tar)
"TerminatedString" — null-terminated string
"TeX" — TeX document format (.tex)
"TeXFragment" — TeX fragment
"Text" — plain text (.txt)
"TGA" — TrueVision Targa format (.tga)
"TIGER" — TIGER/Line GIS format
"TLE" — TLE satellite data format (.tle, .tce)
"TGF" — TGF graph format (.tgf)
"TIFF" — TIFF raster image format (.tiff, .tif)
"TSV" — tab-separated values (.tsv)

"UBJSON" — Universal Binary JSON format (.ubj)
"UnsignedInteger8" — sequence of 8-bit unsigned integers
"UnsignedInteger16" — sequence of 16-bit unsigned integers
"UnsignedInteger24" — sequence of 24-bit unsigned integers
"UnsignedInteger32" — sequence of 32-bit unsigned integers
"UnsignedInteger64" — sequence of 64-bit unsigned integers
"UnsignedInteger128" — sequence of 128-bit unsigned integers
"USGSDEM" — USGS ASCII DEM digital elevation file (.dem)
"UUE" — Unix uuencode format (.uue, .enc)

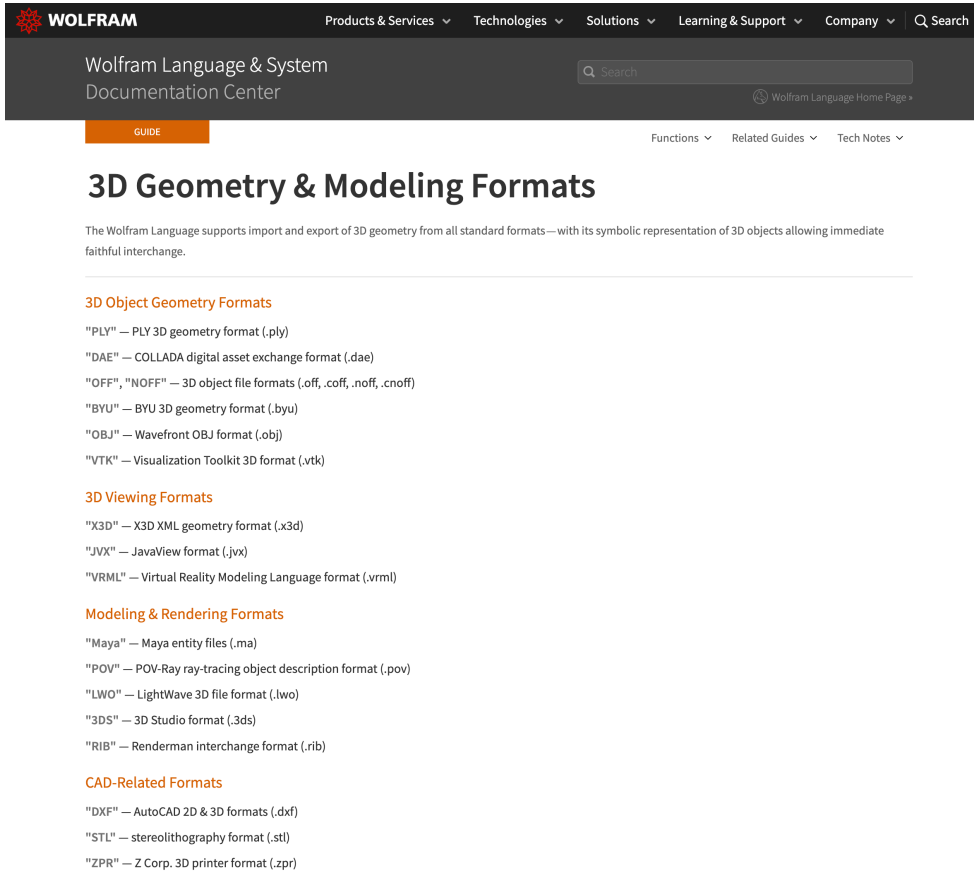
"VCF" — vCard format (.vcf)
"VCS" — vCalendar format (.vcs)
"VideoFrames" — sequence of raster images
"VRML" — Virtual Reality Modeling Language format (.vrml)
"VTK" — Visualization Toolkit 3D format (.vtk)

"WARC" — Web ARChive format (.warc)
"WAV" — Microsoft WAV audio format (.wav)
"Wave64" — Sony Wave64 audio format (.w64)
"WDX" — Wolfram data exchange format (.wdx)
"WebP" — WebP raster image format (.webp)
"WL" — Wolfram Language package source (.wl)
"WMLF" — Wolfram machine learning format (.wmlf)
"WLNet" — Wolfram Language neural net format (.wlnet)
"WXF" — Wolfram exchange format (.wxf)

"X3D" — X3D XML geometry format (.x3d)
"XBM" — X bitmap format (.xbm)
"XHTML" — XML-syntax HTML (.xhtml)
"XHTMLMathML" — XHTML with embedded MathML
"XLS" — Excel spreadsheet format (.xls)
"XLSX" — Microsoft Excel 2007 format (.xlsx)
"XML" — arbitrary XML (.xml)
"XPORT" — SAS interchange format (.stx, .xpt)
"XYZ" — XYZ molecule geometry file (.xyz)

"ZIP" — Windows ZIP archive (.zip)
"ZPR" — Z Corp 3D printer format (.zpr)
"ZSTD" — Zstandard format (.zstd)

3D Geometry and Modeling Formats



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GUIDE

Functions | Related Guides | Tech Notes

3D Geometry & Modeling Formats

The Wolfram Language supports import and export of 3D geometry from all standard formats—with its symbolic representation of 3D objects allowing immediate faithful interchange.

3D Object Geometry Formats

"PLY" — PLY 3D geometry format (.ply)

"DAE" — COLLADA digital asset exchange format (.dae)

"OFF", "NOFF" — 3D object file formats (.off, .coff, .noff, .cnoff)

"BYU" — BYU 3D geometry format (.byu)

"OBJ" — Wavefront OBJ format (.obj)

"VTK" — Visualization Toolkit 3D format (.vtk)

3D Viewing Formats

"X3D" — X3D XML geometry format (.x3d)

"JVX" — JavaView format (.jvx)

"VRML" — Virtual Reality Modeling Language format (.vrml)

Modeling & Rendering Formats

"Maya" — Maya entity files (.ma)

"POV" — POV-Ray ray-tracing object description format (.pov)

"LWO" — LightWave 3D file format (.lwo)

"3DS" — 3D Studio format (.3ds)

"RIB" — Renderman interchange format (.rib)

CAD-Related Formats

"DXF" — AutoCAD 2D & 3D formats (.dxf)

"STL" — stereolithography format (.stl)

"ZPR" — Z Corp. 3D printer format (.zpr)

Algorithmically Generate 3D Models

‹ 3D Printing

Algorithmically Generate 3D Models

The Wolfram Language core principles of automation and unification make it easy to generate geometry and 3D-printable models algorithmically better than ever.

Create 3D-printable objects from 2D images.

```
In[1]:= extrudeImage[image_] :=
          Block[{res, img},
            img = DeleteSmallComponents[Binarize[image, 0.9], 500];
            res = ImageMesh[ColorNegate[img]];
            RegionProduct[res, Line[{{0.}, {50.}}]]
          ]
```

In[2]:= extrudeImage /@ {  }

Out[2]= {  }

Mesh Repair

‹ 3D Printing

Automatically Detect Defects and Repair Meshes

Version 11 integrates fully automated detection of mesh defects in 3D models and provides repair functionality.

HoleEdges edges around a hole in the surface	**TJunctionEdges** edges that form a T junction
TinyFaces faces with near–zero area	**OverlappingFaces** faces that overlap
IsolatedVertices vertices without incident edges	**DanglingEdges** edges without incident faces
SingularEdges edges with more than two incident faces	**SingularVertices** vertices with a non–disc neighborhood
TinyComponents tiny connected mesh components	**FlippedFaces** faces that point inward

Find defects in a 3D model.

```
In[1]:= mesh = ExampleData[{"Geometry3D", "StanfordBunny"}, "Region"];
        FindMeshDefects[mesh]
```

Out[1]=

● hole edges

Reconstruct Models from 3D Data

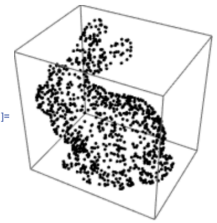
‹ 3D Printing

Reconstruct Models from 3D Data

Version 11 includes state-of-the-art surface reconstruction from arbitrary 3D data.

```
In[1]:= pointcloud = ExampleData[{"Geometry3D", "StanfordBunny"}, "VertexData"];
        Graphics3D[Point[RandomSample[pointcloud, 1000]]]
```

Out[1]=



Reconstruct a 3D-printable Stanford bunny.

```
In[2]:= ListSurfacePlot3D[pointcloud, MaxPlotPoints → 50, Axes → None,
          Boxed → False, Mesh → None]
```

Out[2]=

Properties of Models, Materials, and Costs

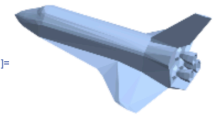
‹ 3D Printing

Get Properties of Models, Materials, and Costs

Leveraging built-in geometric computation and the extensive Wolfram Knowledgebase, properties of 3D models and materials can be computed.

```
In[1]:= model = ExampleData[{"Geometry3D", "SpaceShuttle"}, "Region"]
```

Out[1]=



Mass of the model in aluminum.

```
In[2]:= volume = Quantity[Volume[model], "Centimeters"^3]
Out[2]= 55.5217 cm^3
In[3]:= aluminum (element) ["Density"] * volume
Out[3]= 149.909 g
```

Import 3D Models

‹ 3D Printing

Import 3D Models

Version 11 supports import and export of 3D geometry from all standard formats.

STL	PLY	OBJ	OFF	DXF	DAE	ZPR	VTK	BYU
X3D	JVX	VRML	Maya	POV	LWO	3DS	RIB	XYZ

Import the *Bust of Eleonora Duse*—at the Gallery of Modern Art of the Palazzo Pitti in Florence, Italy—from My Mini Factory repository.

```
In[1]:= Import["https://myminifactory.net/uploads/object-files/1407
          d8e1e51a0cb2fe013fe1fff83fea31cbd224.stl"]
```

Out[1]=

Ready-Made 3D-Printable Models

‹ 3D Printing

Ready-Made 3D-Printable Models

Direct access to a large volume of curated 3D-printable objects, specially organized and created for the Wolfram Language.

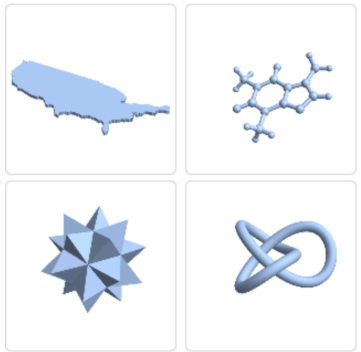
In[1]:= **skull** (anatomical structure) ["Region"]

Out[1]=

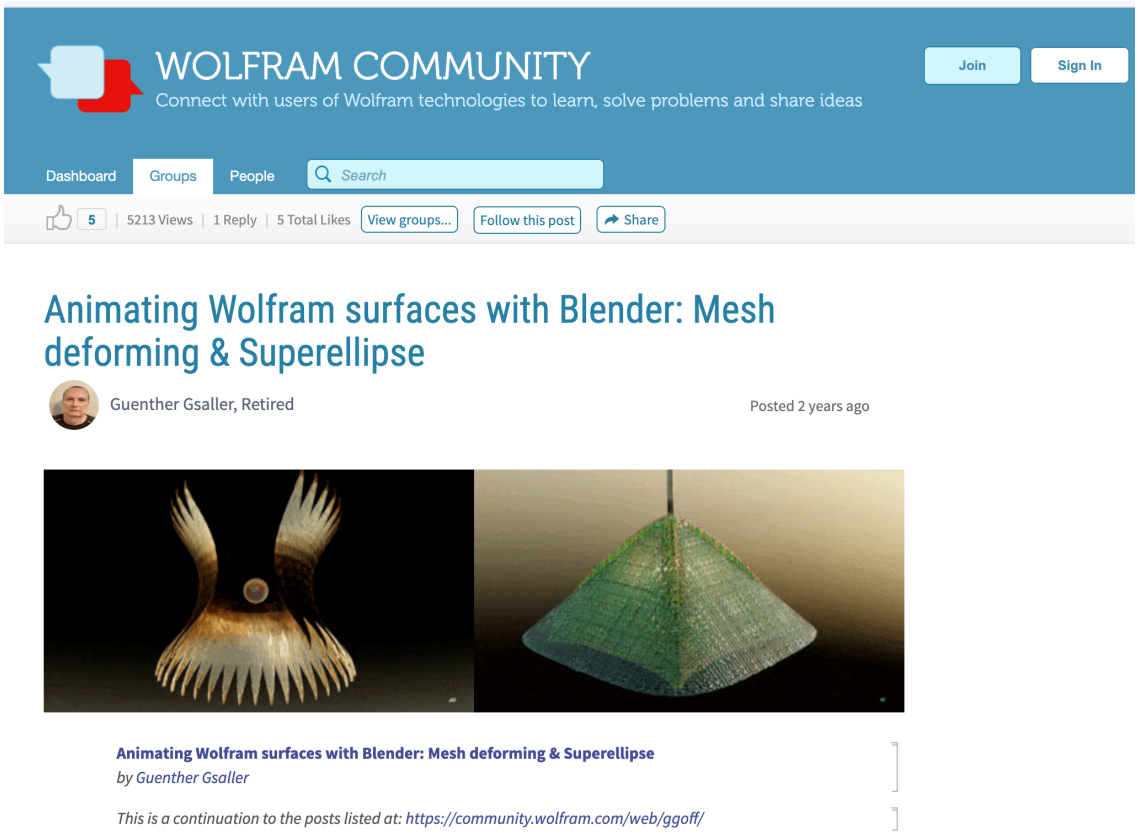
From geographical features to knots.

show complete Wolfram Language input

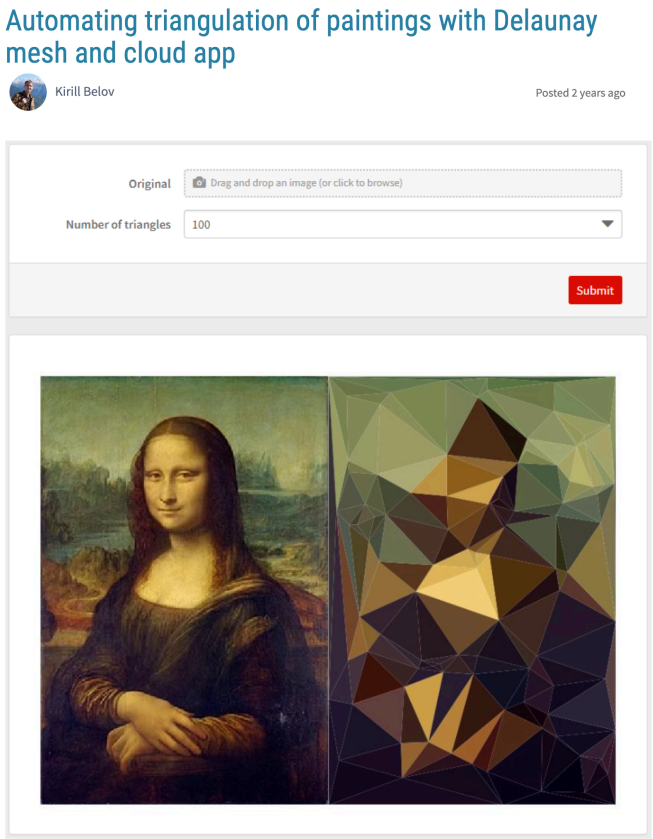
Out[2]=



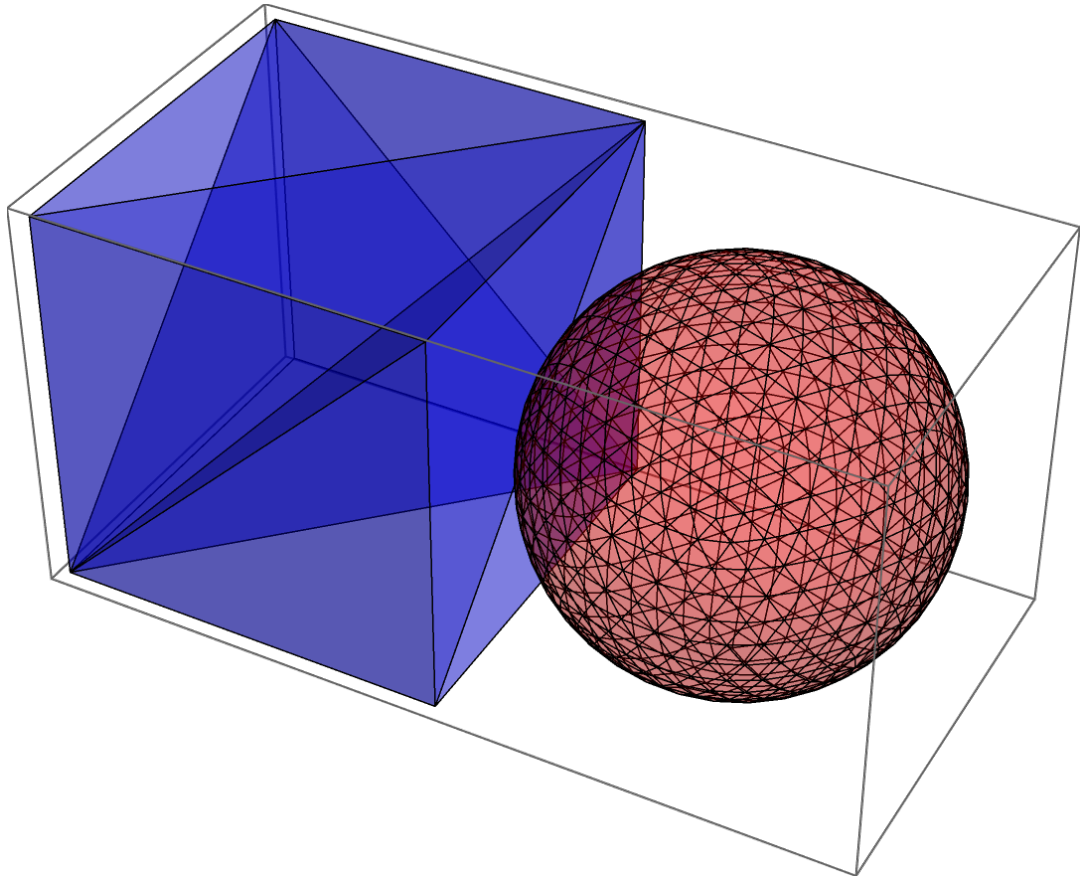
Animation with Blender



Triangulation of paintings with Delaunay mesh

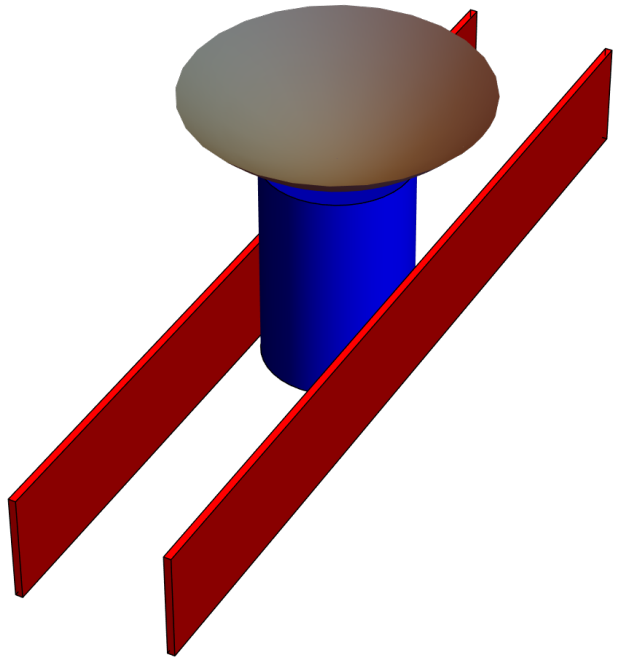


Simple Shapes



Simple Shapes

DanielSat©



Bibliography I

[1] MIT Lincoln Lab. "Target Radar Cross Section". In: Introduction to Radar Systems. MIT Lincoln Lab. MIT Lincoln Lab, 2002, p. 45. URL: https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%204.pdf.

Design Tools for Satellite Models

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