Ave Cruce Salus Mea

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program: Win3ds45 - 3d objects viewer and manipulator.
compiler: flat assembler
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This application don't uses any particular 3d graphic library.

Written from scratch in pure assembler. Thanks to all, who was helping me to do it. Especially:
Jan Pawel II, Tomasz Grysztar, Madis Kalme, Mikolaj Feliks, Lostcauz, Brian Paul, Reverend, Pablo Reda, MHajduk, Ica, James Foley, Andries van Dam, Steven Feiner, John Hughes, Richard Phillips, tthsqe, J. Burkardt, Morgan McGuire, Pierre Bezier, Przemyslaw Kiciak and many others...

Program is 32 bit, needs SSE4 extension in full mode. Basic functionality when only SSE2 technology is present. Achieve full performance on 4 thread CPUs.

After run program shows dialog to open file.

Choose file in 3ds, asc, ply. lwo or md2 format, eventually press ESC to generate object.

Program user interface buttons/keys description:

Vocabulary:

This words and abbreviations I use as synonims:

1. triangles, faces, tris
2. vertices, points, verts
3. coordinate/es, coord/s
4. button/s, butt/s
5 displacement, displac
6. tessellation, triangulize, triangulate
7. program, app
8. coefficients, cooefs
9. option/s, opt/s

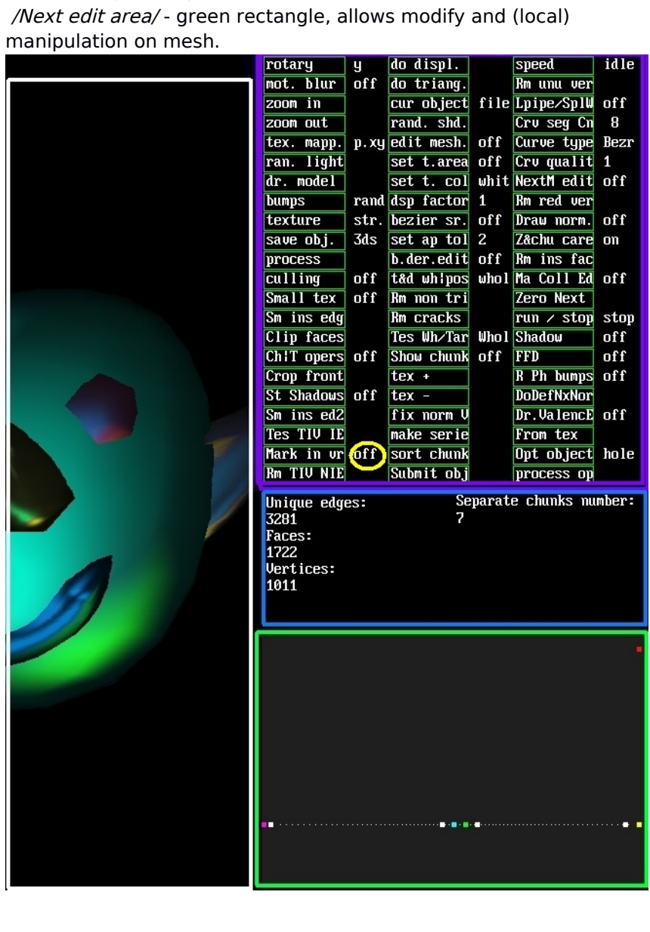
Main content:

Foreword, some general notes:

Many GUI buttons are based on cyclic switching between options ex. 'rotary', 'dr.model', 'bumps', 'texture'.. When last option is achieved, after next pressing button - first option is switched. Buttons have */flag/* - see yellow marked flag example on picture I inserted after next few text lines - short description of option currently switched. For example. 'rotary' button has */flag/* - 'y', 'x', 'z', 'cust'. This means rotate around axis y, x, z and custom rotary using mouse with pressed its button. Some buttons have no */flag/*, after pressing such button only one operation (block of operations) is (are) performed. Such buttons are for ex. 'zoom in', 'zoom out', 'ran. light'. Moreover some options are available parallel, after pressing button or hitting keyboard key. For example choosing render model may be performed through 'dr. model' menu button or space key. Some operations have no GUI button, only key. For now such operations are: X key - load texture, N key - load new 3d object, M key - join 3d object to current existing, 1 key - switching inbetween menu layouts. So, near all key only operations are OS dependent file loading operations.

App window is divided to:

/main part area/ – with displayed current model and eventually some help temporary decorations (ex. edit bars), see marked by white rectangle fragment on screenshot below;
/buttons area/ - on right side of app window, marked using violet rectangle on picture below;
/info area/ - marked by blue rectangle, this area contains some information about mesh – vertices, faces, edges, manifold chunks and others (current) numbers;
/Next edit area/ - green rectangle, allows modify and (local) manipulation on mesh.



note: final 44 release buttons look may be different than above..

Below I try write some information about GUI buttons.

Keys / GUI Buttons description (under left mouse button click):

SPACE key / 'dr. model' button - switching between displaying models: flat, smooth shading, spherical environment, texture, bump, smooth + texture, two texture and bump + texture mapping parallel edges only (smooth shaded, textured lines), point light with shadow light position dependent, real Phongs shading with float normal vector interpolation... Description of actual displaying model on bar located at top of application window.

TAB / 'ran. light' button - generate three nonlinear directional lights (Phongs illumination).

F1 / 'mot. blur' button - motion blur on/off.

F2 / 'cur object' - cyclic switching between objects - from file and predefined: heart (Sanctissimi Cordis Christi) and tetrahedron.

F3/F4 and +/- keys / 'zoom in/out' buttons - no comment.

F5 / 'tex. mapp.' button - choose bumps also texture mapping planar or spherical (planar according to axis X, Y, Z).

F6 / 'bumps' - switching between random bumps and texture dependent.

F7 / 'texture' - select texture: red white stripes, xored, fragment of Mandelbrot fractal also blank white only, (which can be used in smoothing objects edges). App also allows load texture from external file (X key).

F8 / 'save obj.' - choose format you want save 3d model currently shown on screen '3ds', 'stl, 'ply' and 'asc' format are supported. Saving process output goes to current directory. File name has 'object' word and one from alphabet 'A-Z' range letter. Possibility to save file above 65535 elements (triangles, vertices) in 3ds format. To do it - first sort and optimize chunks - use 'sort chunk' button. Saving procedure in stl, ply and asc formats has no limit and problems with more than 65535 elements objects .
Files in 3ds format exported from app can be opened correctly on old versions of Blender or eventually by 3dConverter shareware app. Ply and stl formats is accepted on mentioned above and MeshLab. Possiblility save content of current screen interpreted as sound. Single wave period is taken as shot base. Corresponding flags are 'wav' and 'mod'. Which means standard sound wave fomat and Amiga music module format.

Using 'save obj.' also chunks information can be saved. For now only chunk numbers and binary chunks info structure in the end of file. File, that contains this information is called as 'chunks#.bin', where # is letter.

'process' button – perform save operation in format you select by 'save obj' button.

F9 / 'Culling' - back-face culling on/off.

'Small tex' butt. switches small texture mode. Best visible in Real Phong shading models.

F11 / 'run/stop' button - main rotary on/off.

F12 / 'rotary' - main rotary cyclic switching - around axis X, Y, Z and custom. use mouse and hold it left button in custom rotary cause.

D / 'do displ.' - do displacement mapping texture dependent.

Use 'dsp factor' button to change displacement factor, increase or decrease it.

T / 'do triang' - tesselate the faces of objects. So: divide each face into four smaller faces. Possibility enable tessellation from a separate area - see 'set t. area' button description.

Some info related:
'Tes Wh/Tar' button - Sets the flag of this button to 'tesA' means tessellation content of object from selected area. Flag 'Whol' means tessellation of the entire object after pressing 'do triang' button described in this paragraph.
't&d wh|pos' button - Sets the flag of this button to 'posi' means tessellation of only the positive (+) coordinates of the vertices. Flag 'whol' - tessellation of both positive and negative coordinates vertices based on faces...
To apply the correct iteration of the tessellation of only a part of the object, removal of all cracks (see "Rm cracks") is mandatory, all cracks must be removed.

U / 'rand. shd.' button - random point (spot) light position and obliquity of plane on which shadow falls. Use 'Shadow' button to display.

V / 'edit mesh.' button - edit option, possibility to edit according to vertex, single face or edge. Use left mouse button and yellow handlers.

W / 'set t. area' button - set tessellation area - default is whole screen (some margin is not used).

C / 'set t. col' - set color that will by bypassed when displacement and 'from tex' menu operation was launched. Available options - black 0x00000000, white 0x00ffffff.

F / 'dsp. factor' - set displacement factor, determine displaced bumps higher or lower. This butt also determines normal vector tolerance in merging vertices feature – use 'Rm red ver'. This button allow control twist factor. To launch twist feature use 'FFD' button – set its flag to 'twis'.

B / 'Bezier sr.' button - select Bezier patches, which will be calculated and displayed. Now are predefined four Bezier-patch objects - tea pot, tea cup, tea spoon and a cube. Possibility to edit such patch based object, (see 'b.der.edit' button description). Press button and set its flag to 'triP' app will attempt to calculate single Bezier triangle patch (treat triP option as be in prealpha stage) .

A / 'set ap tol' button - set approximation tolerance when removing redundant vertices (merge vertices) is launched. When vertices are enough *near* they may be collapsed using 'Rm red ver' button. 'set ap tol' button sets how much *near* vertices to collapse should be. This button also determine space between cloned/copied object (see 'make serie' button description). Also using this button user can change pipe diameter. This operation is performed after hitting 'Long pipe' button; - So this butt have many purposes, and its flags (integer numbers) indicates many situations.

E / 'b.der.edit' button - draw Bezier derives, selected by B key, 'Bezier sr.'button. Possibility to edit Bezier patches by stopping animation (button 'run/stop') and move yellow bars with pressed left mouse button. When left button is released new position of bar is accepted. Bezier patches are recalculated permanently. To achieve previous geometry restart app.

't&d wh|pos' button - when displacement or tesselation are performed (use butt do displ.' for displacement, 'do triang' for tesselate) determines which part of object is affected. Flag -> 'posi' means that only positive 'z' coefficients vertices are affected, if set on flag -> 'whol' all vertices are affected during displacement / tesselation process.

S / 'speed' button - toggle animation speed. Flags 'idle', 'full'. Some rendering models use only two threads, some four, a few displaying models (edges , nodes) only one.

'Rm unu ver' button - remove unused vertices, other words remove this vertices that indexes are unused in triangles list. This option make vertices list shorter.

'culling' button switch backface culling default set 'off'.

P / 'Lpipe/SplW ' button - make long multi segment pipe or mesh with wall based on rotated curve. Base polynomials, according to 'Curve type' button can be: Bspline, Catmull-Rom, Hermite spline or Bezier curve. If flag appropriate to this button is equal 'edit' -> editing pipe mode is switched – press and hold left mouse button on yellow bar to move node. Press and hold right mouse button and move mouse - rotate pipe project. By pressing once again 'Long pipe ' button -> set flag to 'pipe' - calculate and render pipe, its diameter according to flag of 'set ap tol'. Setting flag to 'wall' - calculate 3d object with wall based on rotated, choosen previously, curve. You still may edit shape of pipe or solid using control bars, when butt is switched to 'pipe' or 'wall'.

'Crv seg Cn' menu button - determine spline segments count. More info see above 'Lpipe/SplW' button description.

'Crv qualit' - determine spline object quality (triangles count per segment). See buttons description above.

'Curve type' button - determine type of curve that is base to making two kind of objects: "long pipe" and objects with wall based on rotated spline. Flag available now 'Bezr' - Bezier, flag 'Bspl' - Bspline type, 'CatR' – Catmull – Rom, 'Herm' Hermite. When Hermite spline was chosen to edit, possibility to modify its bias and tension. Press 'NextM edit' button and set its flag to different than 'off' This way you are able to modify this Hermite spline features. Just move mouse cursor on */Next edit area/* and drag green bar when left button is pressed.

'to pieces' – push butt and set it flag 'on' perform shatter object animation effect. Push again, set 'off' – return to orginal object.

H / 'NextM edit' menu button - use */Next edit area/* that allow basic edition on:

1. *Next* 3d object - joined to earliest loaded mesh (use key 'M'). Flag is 'Nx.O'

2. Manifold chunk. Flag is 'chun'

3. Whole object. Flag is 'whol'

4. Whole part of object from tesselate area. Use 'set t. area' button to select area you need. Flag is 'area'

5. Sketched part of object. Set flag to 'sket' and mark with mouse and pressed left button region of intrest. App will calculate vector according to sketched pixels. At ends of sketched curve app will mark two lines, prependicular to computed vector and draws it. Next flood fill two regions. (All operations non visible to users eye.) Blue region - blue vertices is base part of object ready to deform. Red region - red vertices is part of object rigid connected with blue one. App calcs rigid convolution matrix according to boundary of base one. Now 4 transitional triangles are taking into account. Rigid region is always below base region on screen area. Marked part of object should have enough verts count.

6. Sketched, non rigid. Corresponding desc above. Only one region is marked. Pixels prependicular to sketched curve and all below, visible as separate, no occluded part of object.

After 'NextM edit' butt was pressed, app, draws bars on, I called, */Next edit area/* below menu buttons and info area. Bars meaning: blue bar on this */Next edit area/* determines 'X', 'Y' position, violet bar determines 'Z' position, yellow bar determines scale of selected (points 1. - 6.) part of mesh, red bar position - allow rotate around center point this part of 3d object, green bar allow non-regular scale, only along 'X' and 'Y' axis. White bars - set bend process of object, Bezier (white dots) curve dependent (for now looks good on low poly objects) . Moving bars (with mouse and its left button) perform change parameters described above. Only vertical position of violet and yellow bars can be changed. If flag appropriate to this button is set on 'chun' it enables separate chunk edition possibility. Press 'Show chunk' button and set its flag to 'on' - app will display bar on every triangle, unique to chunk possessed of this triangle. Click with left mouse button on bar and choose current chunk you will edit. Now user can edit whole selected manifold chunk, moving colored bars displayed on */Next edit area/.*

'NextM edit' button also sets which part of object user may edit via free form deformation - 'FFD' button.

O / 'Draw norm.' button - when flag of this button is set on 'tri.' drawing faces (triangles), when on 'vert' drawing vertices dependent normal vectors.

'Rm red ver' button - removing redundant/merge vertices, according to approximate tolerance value of distance inbetween verts to (use 'set ap tol' button to set this value). Removing redundant, enough near vertices option is processed only on verts placed in tessellate area - set this area using 'set t.area' button.

By pressing 'dsp factor' button user may set tolerance of normal vectors possessed by vertices to merge ..

R / 'Z&chu care' button - when set 'on' - take care about 'Z' coefficient of vertex during remove redundant vertices operation. When flag appropriate to this button shows 'chun' means that collapse/merge vertices operation dont destroy manifold chunks structure of object.

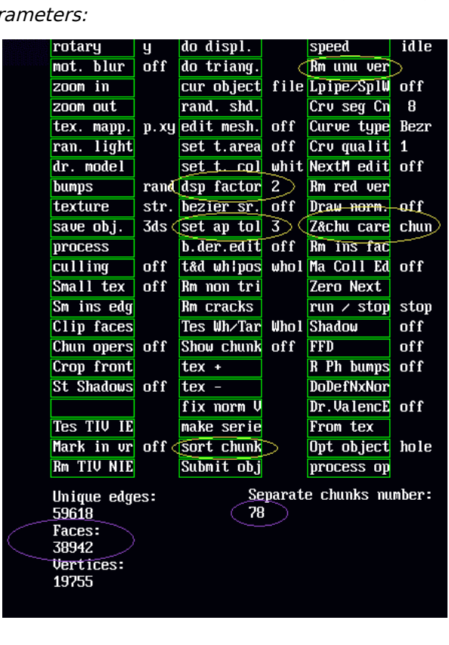
Flag 'off' means care on only on 'X' and 'Y' position of vertex. 'Rm red ver' button - perform removing redundant vertices operation (merging vertices).

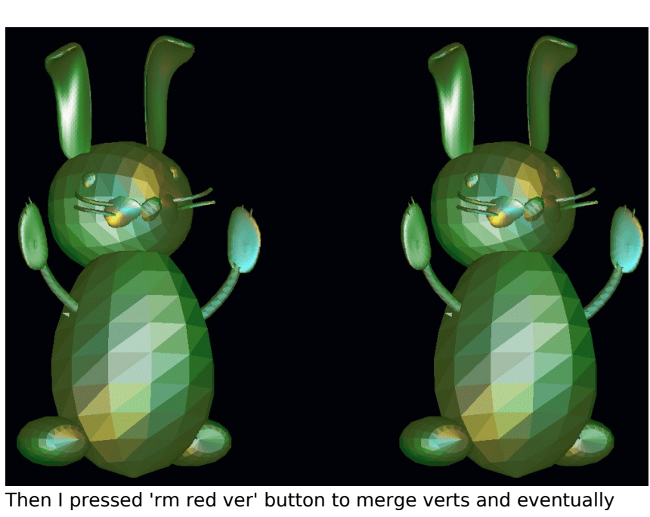
On pictures below I present attempt to simplicity object by merging vertices and not destroy chunks structure.

I try describe operation:

First I set 'Z&chu care' button on 'chun'. Than I set 'dsp factor' and 'set ap tol' buttons on values I want achive, accordingly: tolerance of how similar normal vectors of merged verts should be, and tolerance how near mentioned vertices should be. Moreover I press 'sort chunk' button to be sure every chunk has its continuus part in verts list (yellow ellipses). My test object has 38942 faces and 78 chunks (violet ellipses on picture).

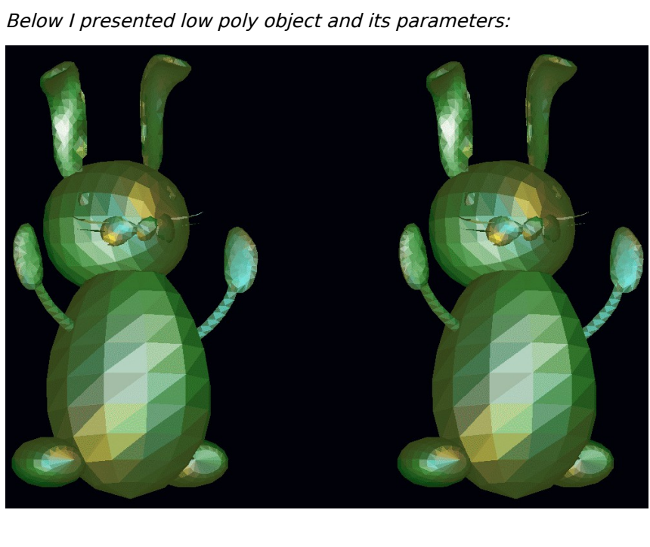
Below I presented buttons configuration, example high poly object and its parameters:

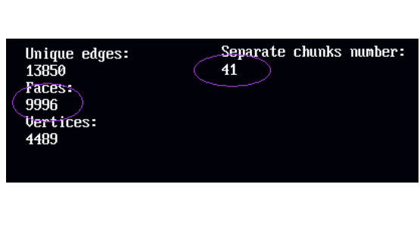




Then I pressed 'rm red ver' button to merge verts and eventually 'rem unu ver' to recalculate normal vectors. As its visable on pictures below, faces count decreased to 9996. Unfortunatelly chunks number was not preserved, decreased from 78 to 41. It was not reasonable (ex. rabbits paws and claws as a small element completely desappear)

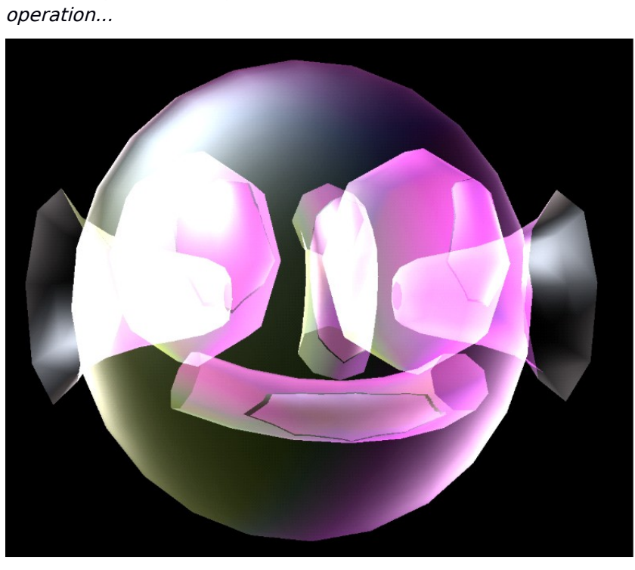
Below I presented low poly object and its parameters:

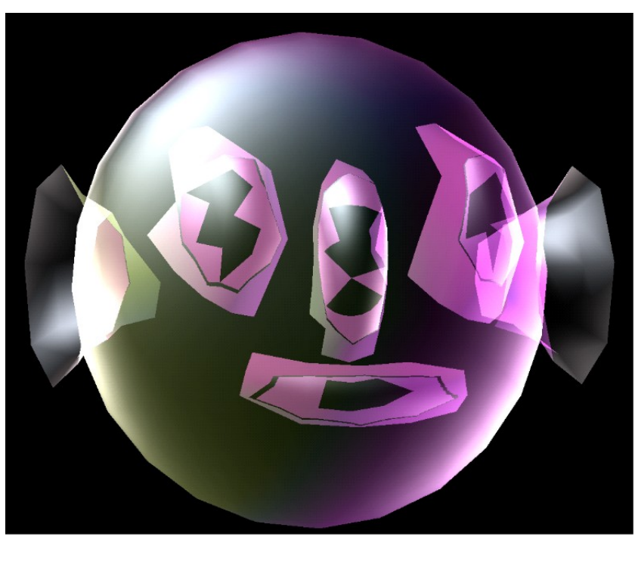




'Rm ins fac' button - try to remove inside faces - that are covered by other faces outside mesh. This operation reduces faces and vertices number. Removing operation is solved by multi time rotating and projecting on about 1000x1000 pixels area (not displayed), works correct when projected front triangles area is not smaller than 1 pixel. Currently operation uses 4 threads. Be patient - it take some time no matter how complex is 3d object. (But calculations on bigger objects, that contains many vertices and faces for sure will take bigger period of time).

Below are presented object before and after remove inside faces operation...

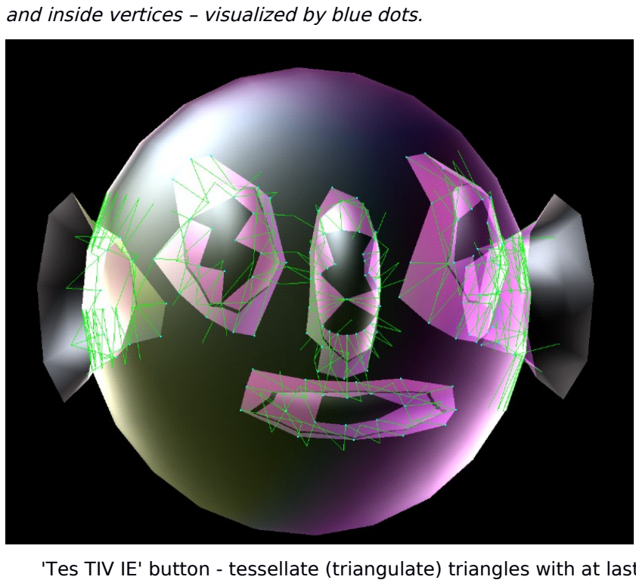




'Mark in vr' button - searching for inside vertices option. Vertices are counted. This value is displayed on */info area/* - below buttons menu area. Calculations may take some time - are done through many parallel projections.

'Ma Coll Ed' button - mark and count - number displayed on */info area/* - collided edges. It means edges that intersect other triangles. Flags allowed for button 'off' and 'on'. This operation will be slow on very complex objects. Brute force n to n solving method. Process use 4 threads for now.

Below is presented object with marked green intersected edges and inside vertices – visualized by blue dots.



'Tes TIV IE' button - tessellate (triangulate) triangles with at last one inside vertex and at last one edge that intersect. First 'Ma Coll Ed' - mark collided edges and 'Mark in vr' - mark inner vertices buttons flags must be set 'on'. Don't forget about removing cracks from triangle net ('Rm cracks' button).

Operation performed correctly on object presented on picture below...

'Sm ins edg' button - smooth inside edges. This option try improve inside structure of mesh. After removing inside faces (which is simplification option), inside edges adjacent to faces/triangles that are removed, are usually jagged. This option try to fix such situation. Some small margin is leaved. Sometimes proces sholud be repeated. Mesh geometry improvement effect will be best seen in transparent rendering models. Procedure require seting of all normal vectors of object on outside.

'Sm ins ed2' butt - smooth inside edges. Bit other algo. Object may have any normal vectors configuration.

Below is presented some partly successful attempt of 'smooth inside edges' process.. Only mouth and ears shape of face schema object seems to be corrected OK..

'Clip faces' - clip faces that are in tessellate area. Such area can be set using 'set t. area' button.

'Crop front' button - crop front (of view area) faces, some small margin (a few degrees in each direction) is leaved.

'Ch|T opers' button. Separate chunk and triangle operations. By pressing this button and setting its flag to 'Cinv' - ability inverse sense of normal vectors from separarate chunk. Flag 'Ctes' allow tesselate selected chunk. Flag 'Cmir' allow perform mirror copy Y axle depend. Flag 'Cdel' - delete chunk. Flag 'Trem' - remove single triangle job.

Flag 'Cmer' allow merging vertices from only one chunk. In addition if you want use this feature press 'Z&chu care' button and set its flag to 'chun'. Moreover use 'sort chunk' to optimize object. Use 'dsp factor' button and 'set ap tol' to set tolerancy of: normal vector and distance inbetween vertices to merge. This chain of activities allow correct use merge option.

Flag 'Cgeo' allow perform geometric modify operation, use 'opt object' button to select operation you want process. So with this functionality you may fill holes or decrease lenght of every shortest edge in triangles apropriate to separate chunk.

Flag 'CinV' – mark vertices inside closed volume of chunk.

Flag 'CrFR' – delete front faces of selected chunk. First mark inner vertices, use 'Mark in vr' buton.

To use chunks features of this button ('Ch|T opers'), do as follow:

Press 'Show chunk' button and set its flag to 'on'. Pause animation using 'run/stop' button. Move mouse cursor on unique triangle mark (bar with unique color, in center of triangle, separate to each chunk) and click with left mouse button. On selected chunk will be performed appropriate, according to flag of 'Ch|T opers' button operation.

'Ch|T opers' butt allow triangle option. Now only one: 'Trem' - delete single triangle option. Press 'edit mesh' butt, set its flag to 'face'. Click on yellow bar in center of triangle you want remove.

'St Shadows' - performs calculating shadows based on stencil depth buffer. Visible only in Texture mapping and Real Phong" rendering models.

'Rm TIV NIE' button - remove triangles with at last one inside vertex and without any intersected edge. First 'Ma Coll Ed' -> mark collided edges and 'Mark in vr' -> mark inside vertices buttons flags must be set 'on'.

'Rm non tri' button - some triangles have duplicated, or even tripled index of vertex - so it geometric representation is line, or point - remove such triangles to save memory space.

'Rm cracks' button - remove cracks. After tessellation of chosen area of object (not whole) may take place such unneeded artifact: Along edge may occur vertex that only touch edge but is not possessed by this edge. Routine appropriate to this button cure this situation. Operation may require repeating to patch all cracks. Removing all cracks is obligatory to iterate correctly tessellation/triangulation operation when not whole object is affected. I suggest user to click this button several times until triangles count visible on */info area/* becomes stable. See 'do triang.' button description.

'Tes Wh/Tar' button - set tessellation mode (under 'do triang' button). If flag of this button is set to 'tesA' -> area tessellation. Setting flag of 'Tes Wh/Tar' button to 'Whol' means whole object tessellation after pressing button 'do triang.' button.

'Show chunk' - show manifold chunks bars, color is individual for each chunk.

'tex +', 'tex -' buttons - changes 'zoom' of texture mapping. Visual effect may be different in various rendering models - (clipped/tiled/..).

'fix norm V' button - fixing normal vectors option - Do random rotary and parallel projection two times with disabled and enabled backface culling. Triangles that was rendered first time and not second time have non correct sense of normal vector. (Render operation is performed only in inside memory area, not displayed on screen.) Pressing a few times this button make possible cure mismatched sense of normal vectors. Use this option when mismatched normal vectors are inside separate chunk. If whole chunk has uncorrected normal vectors - better use 'Chun opers' option and button.

'make serie' button - make copy of current object, and display this copy with increased current 'X' coord value - this value determines 'set ap tol' button flag/value.

'sort chunks' - Rearrange vertices list - tried perform situation when every chunk of has one continuous part of this list. Use this button before saving to 3ds file when object has above 65535 elements. And before other chunk edit options.

'Submit obj' - this button allow submit changes after edition. I mean both: */Next edit area/* and free form deformation edition. For more details see 'FFD' and 'NextM edit' buttons description.

'Zero Next' button restarts *Next variables* - showed as color bars on */Next edit area/* . Also FFD (free form deformation) patch net will be set at it's start position.

'Shadow' - display flat shadows on current texture.

'FFD' button - allows free form deformation based on single Bezier patch ('patc' button flag), Bezier volume ('vol.' flag) or single spline ('spli' flag). Green lines and yellow bars are displayed. Use left mouse button and drag yellow bars to preform operation. Possibility to make deformation on whole model (as default) or only part. In this cause use 'NextM edit' button to select apropriate fragment. With 'FFD' button also 'twis' flag is associated. Use this feature to twist selected fragment. Use 'dsp factor' butt to increase effect.

'R Ph bumps' button - switch rendering bump mode in Real Phong based models. Currently - "texture + Phong" and "glass".

'DoDefNxNor' button - do deformation according to */Next/* joined object (loading by 'M' button). According to its normal vectors. Use 'set ap tol' button to increase/decrease effect.

'Dr.ValencE' button - mark valence - single edges located at border of manifold chunk. (sadly operation many times give false verdict).

'From tex' button - allow transform current texture to 3d object. Basic pixel to voxel operation is performed. Before operation procedure check if process is possible. If no, operation is abandoned. Sometimes verdict is not correct (crash). Use 'set t. col' button to select background color.

'opt object' button - allow selecting operation to modify object geometry. Flag set on 'hole' means function that fill triangle holes in mesh. Flag set on 'geom' perform operation that should improve geometry – situation when all tris has angles are about 60 degrees and every edge equal. Push button, I describe functionality now, set its flag to 'edge' – switches decreasing shortest edge in every triangle, that mesh contains. Now user may collapse such shortened edge and one of vertex it's based. In this case use 'dsp factor' and 'set ap tol' buttons to set tolerance how near should be vertices to merge and how similar must be normal vectors of this vertices. Under 'opt object' butt ('Rcln' flag) also remove clenched triangles feature.

'process op' button – execute operation you select by 'opt object' butt.

Second layout buttons (press '1' key to switch inbetween layouts):

'morph' - morph current object to one triangle.

'wave' – draw wave according to current screen content and */Next edit area's/* blue bar position.

'Rm all TIV' - remove triangles with all three vertices marked as inner.

'Tess inter' - tesselate triangles intersected by edge. I put new vertex at intersection point.

'Sketch obj' – sketch new object by holding pressed left button and move mouse. Every pixel is changed into tetrahedron.

Mouse wheel operations:

1. As default: changing geometry of object by making eliptical bumps. Set bump shape by moving blue bar displayed on */Next edit area/* . First set flag of 'NextM edit' button other than 'off' – you will be able move this bar. Its X and Y positions sets apropriate half axes of base elypse. Roll wheel up or down to create concave or convex effect. Note: To see effect in object should be enough tesselated.

2. When editing vertex, face or edge mode is switched - 'Z' position of chosen element will be modified. Roll up = decrease 'Z' coordinate, roll down = increase.

Key only operations:

X key - load texture (raw format 512X512 pixels 24bit 0xRRGGBB). I tried bmp format, (uncompressed 24, 8, 4bit win and os2 versions) but it is very buggy (best parameters, that increase loading success for bmp texture are: color = 24 bit, resolution = 512x512).

N key - load new mesh accepted formats are 3ds, stl, asc, binary little and big endian ply, md2 and LightWave3d 5.x big endian lwo. (old mesh will be abandoned).

M key - load new mesh and join it to the old. Possibility to edit parameters of fresh load mesh using 'NextM edit' button. See description of this button for details.

1 key – switch forth and back to second buttons layout.

ESC key - exit.

Right mouse pressed button and move - setting position of texture, (works in all drawing models, but is visible only in texture displaying models).

General note about implemented operations. - Some of it may run terrible slow especially on 'large' objects. Maybe some tests for low detail objects may prevent your speed disappointing. Note that even operations on small objects may be slow, because way of solving problem. Its 32 bit app, so object above ~10 000 000 vertices/faces may be too big for 4GB RAM limit - some operations allocate temporally many memory (because using memory greedy pivot lists). Many operation cannot be launched parallel in the same time (ex. editing / chunks / Bezier patches / long pipes).

"No work is ever complete,
and this one is no exception."
Pierre Bezier