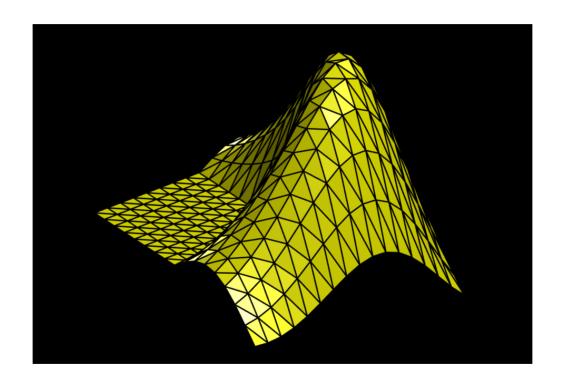
Vectorized mesh processing toolbox in Matlab



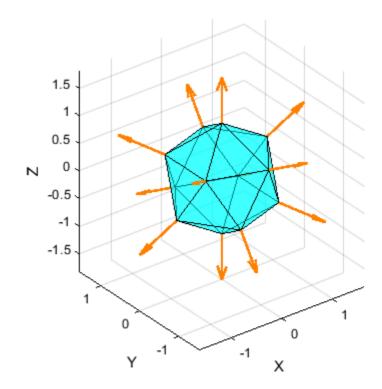


I Vertex normals

Principle: mean of face normals in a given neighborhood

```
addpath('data/');
addpath('src/');

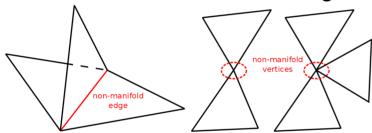
load('icosahedron.mat');
ngb_degre = 1;
select_vertex_normals(V,T,ngb_degre);
```



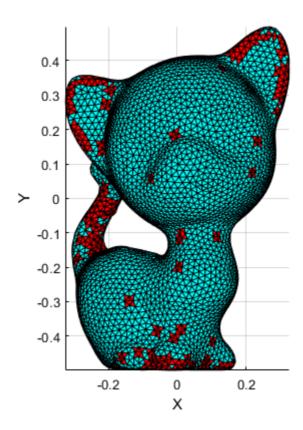
II Compute and select non manifold triangles

Principle: a non manifold edge is shared

between 3 or more triangles.



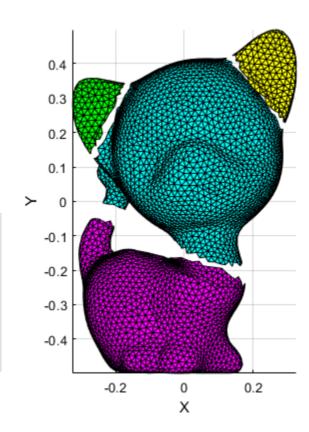
```
load('kitten_nmnfld.mat');
nmnfld_tgl_idx_list =
select_non_manifold_triangles(V,T);
view(0,90);
```



III Compute and select connected components

Principle: triangle neighbor search 'glutton' algorithm.

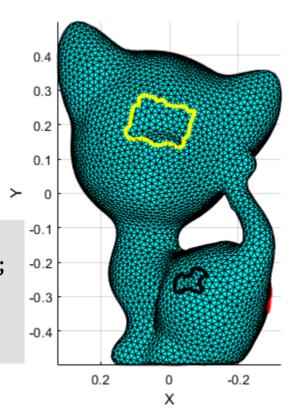
```
load('kitten_components.mat');
[cc_nb,components] =
segment_connected_components(T);
show_mesh_components(V,components);
view(0,90);
```



IV Compute and select holes and boundary

Principle: detect and reorder non shared edges.

```
load('kitten_holed.mat');
nmnfld_vtx_idx = select_non_manifold_vertices(V,T,false);
[V,T] = clone_solve_nmnfld_vertices(V,T,nmnfld_vtx_idx);
boundaries = select_holes_and_boundary(V,T);
view(0,90);
```

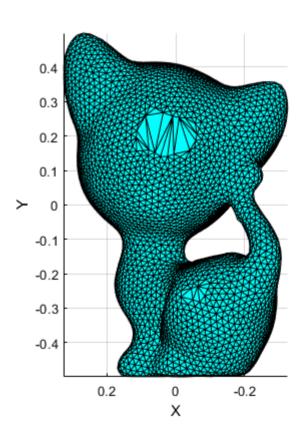


V Fill mesh holes

Principle: without data / point addition. prior sharp angles and curvature.

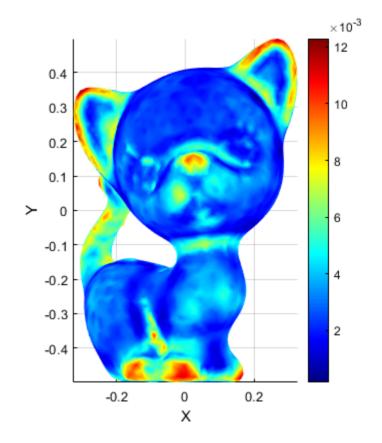
```
[V,T] = remove_non_manifold_vertices(V,T);
boundaries = select_holes_and_boundary(V,T);
view(-180,-90);

Perimx = 200; % max perimeter length
T = fill_mesh_holes(V,T,boundaries,'closed',perimx);
plot_mesh(V,T);
view(-180,-90);
```



VI Compute and show curvature

```
load('kitten.mat');
ngb_degre = 2;
N = compute_vertex_normals(V,T,ngb_degre,'raw');
Curvature =
compute_mesh_curvature(V,T,N,ngb_degre,'mean');
show_mesh_curvature(V,T,curvature);
view(0,90);
```

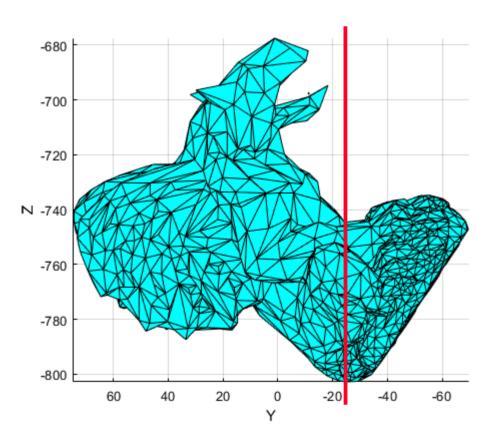


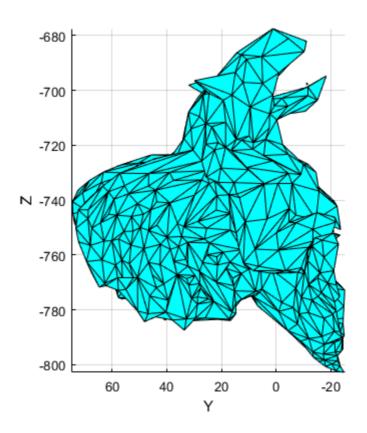
VII Mesh subselection : principle

Principle: localize vertices in the right part of the half space. Deduce edges and triangles belongings or not to submesh.

```
load('Gargoyle 3k.mat');
plot mesh(V,T);
view(-90.0);
N = [0 \ 1 \ 0]; \% plane normal vector
I = [0 -25 800]; % one point belonging to the plane
[V_out,T_out] = submesh_selection(V,T,n,I); % Gargoyle top part
plot mesh(V out, T out);
view(-90,0);
```

VII Mesh subselection : results



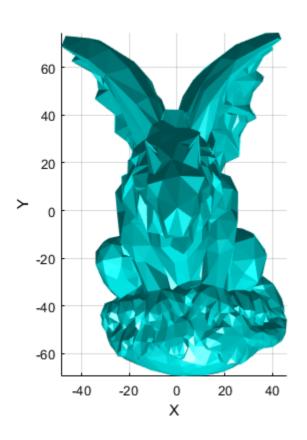


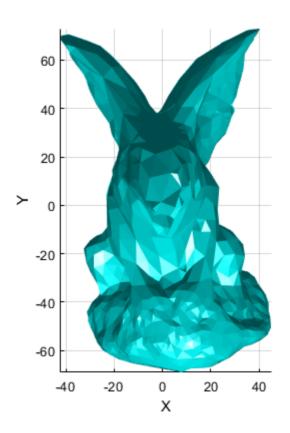
VIII Mesh smoothing : principle

Principle: vertex is replaced by the mean of its local neighbors.

```
plot mesh(V,T), shading interp, camlight right;
view(0,90);
N = compute vertex normals(V,T,2);
nb iterations = 1;
ngb degre = 1;
V = mesh_smooth(V,T,nb_iterations,ngb degre);
plot mesh(V,T), shading interp, camlight right;
view(0,90);
```

VIII Mesh smoothing : results





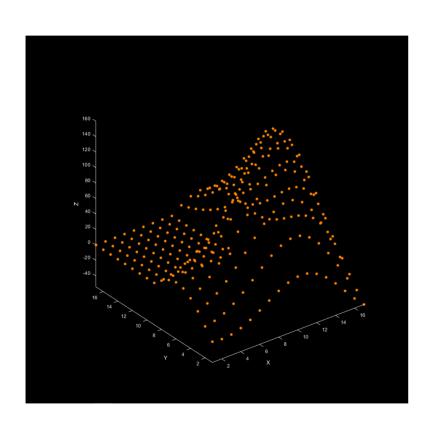
IX Convex hulls : principle

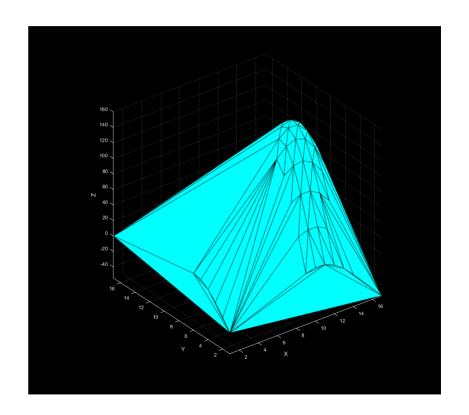
```
nb vtx = 128;
X = 2*(rand(nb vtx,1)-0.5);
Y = 2*(rand(nb vtx,1)-0.5);
Z = 2*(rand(nb vtx,1)-0.5);
Rho = X.^2 + Y.^2 + Z.^2;
i = Rho <= 1; % keep points inside the unit sphere
X = X(i);
Y = Y(i);
Z = Z(i);
V = cat(2,X,Y,Z);
plot_point_set(V, 'o', 'y', 4);
axis equal, view(3);
[V,Qh] = quick hull(V);
plot mesh(V,Qh);
axis equal, view(3);
```

Principle:

Divide and conquer/quick hull algorithm with inside points removal or gift wrapping/Jarvis algorithm.

IX Convex hulls: results

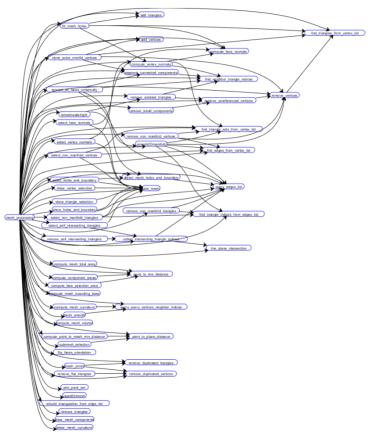




Sources & test functions : many more

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- flip_faces_orientation	- ind_wiangle_sets_worm_vertex_list (indices separated in a cell array)		
- ismesh2Dmanifold x test_query_every_vertices_neighbor_indices - ismeshvatertight x test_remove_no	- ind_triangles_from_vertex_list (all indices together)		
- ismest valentight x test_remove_si_triangles - invert_face_orientations x test_remove_non_manifold_triangles - line_plane_intersection x test_remove_non_manifold_triangles - line_plane_intersection x test_remove_non_manifold_vertices - mesh_sm ooth x test_remove_self_intersect_tgl - mesh_union x test_remove_self_intersect_tgl - test_remove_self_triangles - test_remove_non_manifold_triangles - test_remove_self_triangles - test_remove_non_manifold_triangles - test_remove_self_intersect_tgl - test_remove_self_intersect_t			
- invert_face_ofientations			
- line_plane_intersection			
- mesh_smooth x test_remove_self_intersect_tgl - mesh_union x test_remove_smail_components - plot_mesh x test_reontent_all_faces_coherently - plot_point_set x test_show_components - point_to_line_distance x test_show_holes_and_boundary - point_to_lane_distance x test_segment_connected_components			
- mesh_union x test_remove_small_components - plot_mesh x test_remove_small_components - plot_point_set x test_show_components - point_to_line_distance x test_show_holes_and_boundary - point_to_lane_distance x test_segment_connected_components			
- plot_mesh x test_reorient_all_faces_coherently - plot_point_set x test_show_components - point_to_line_distance x test_show_holes_and_boundary - point_to_plane_distance x test_segment_connected_components			
- plot_point_set x test_show_components x test_show_down holes_and_boundary - point_to_line_distance x test_show_noles_and_boundary - point_to_lane_distance x test_segment_connected_components			
- point_to_line_distance xtest_show_holes_and_boundary - point_to_plane_distance xtest_segment_connected_components			
- point_to_plane_distance x test_segment_connected_components			
	- quad2trimesh	x test_select_holes_and_boundary	
- query edges list x test submesh_selection		x test submesn_selection	
- query_every_vertices_neighbor_indices			
- rebuild_triangulation_form_edge_list		III	
- remove_duplicated_triangles			
- remove_duplicated_vertices	- remove_duplicated_vertices	II .	

Functions dependancy graph



Documentation

Each file integrates its own header help / documentation :

```
%% detect mesh holes and boundary : function to detect vertices which are part of
% the mesh boundary and list their indices in boundary vectors.
% Author & support : nicolas.douillet (at) free.fr, 2020.
% From the vertex and triangle lists, this function computes
% the mesh boundaries when there are some (opened surface
% or presence of holes in the mesh).
% Principle is based on detecting and sorting non shared edges.
% Input arguments
       [ \mid \mid \mid \mid \mid \mid ]
% - T = [i1 i2 i3], positive integer matrix double, the triangulation, size(T) = [nb triangles,3].
%
       [ \mid \mid \mid \mid \mid \mid ]
% Output argument
% - boundaries : cell array of positive integer row vectors double, size(boundaries) = [nb_holes,1].
                                                                                  - 16 -
```

On going and upcoming developments (1)

- Rebuild triangulation from disordered edge list **
- Mesh_simplify with quadric_edge_collapse *****
- Mesh slice **** ✓
- Improve curvature computation ****
- Mesh split & stich ****
- Mesh smooth : + cotan option ***
- Improved fill holes + select the hole by its id ***

On going and up coming developments (2)

- Mesh refinement ✓
- Merge_close_vertices
- remove_unacceptable T_vertices
- speed up algorithms with hybrid for loop / vectorized; enable // computing (parfor)
- Mesh segmentation
- Intersection of two meshes

Inspirations: Meshlab



CGAL



Links to download

Github:

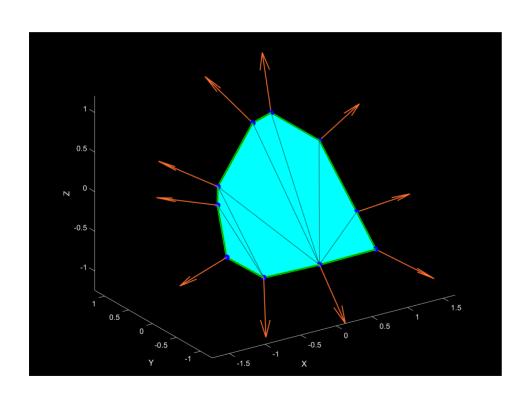
https://github.com/NicolasDouillet/mesh_processing_toolbox

Mathworks file exchange:

https://fr.mathworks.com/matlabcentral/fileexchange/77004-mesh-processing-toolbox?s_tid=prof_contriblnk



More to come: mesh generation toolbox



Discrete contour mesh patch ✓

- Same principle as fill mesh holes
- No triangle context
- Automatic contour points reordering
- 3D or 2D

Multiresolution mesh

From the quick hull divide & conquer algorithm principle. Reverse way for concavities.