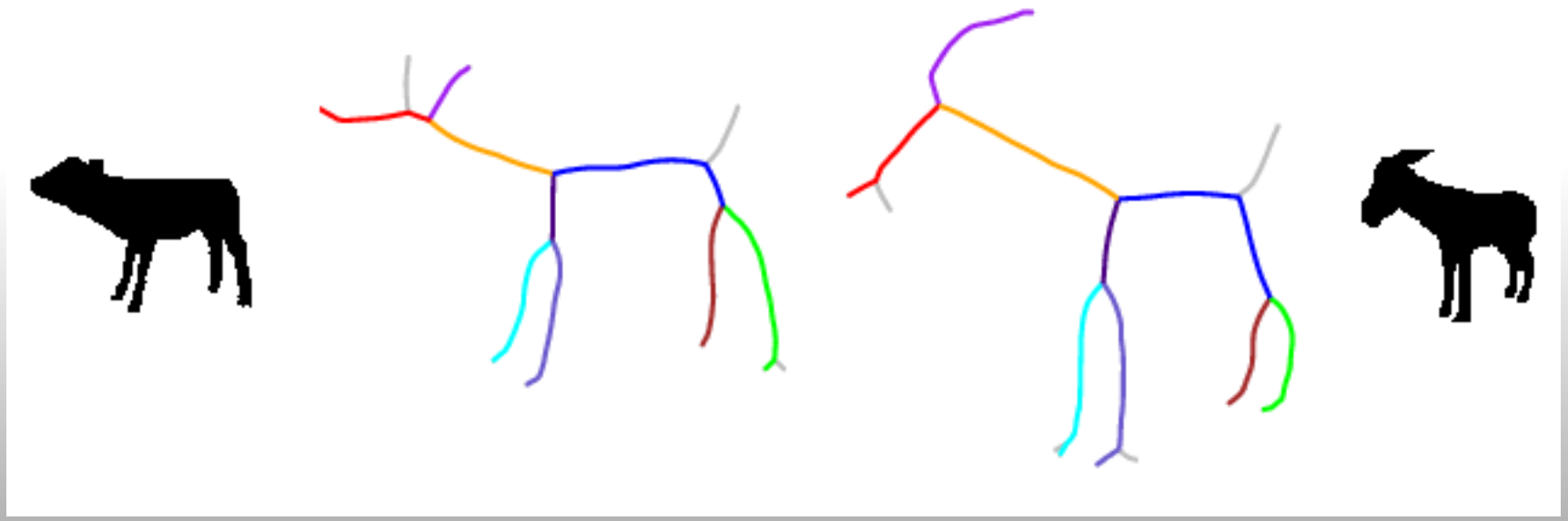
MEDIAL AXIS TRANSFORMATION

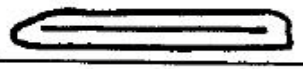
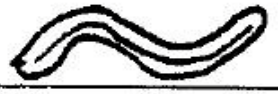
Motivation :Describe a shape

- Ways to describe shape :
- Edges, Contours :Local properties, need to be linked to global structures by edge linking and grouping
- Hough transform : Global grouping, restrictive shape
- Topology : Very general
- Geometry : Very restrictive



Shape Description using MAT

Example: Qualitative & quantitative characterization

			
# segments	1	1	1
point types	ENN...NNE	..	..
length	L	L	L
shape	worm	worm	worm
axis	straight	right-/left-circular	spiral left
axis curvature	∅	neg/pos	pos
axis curvature change	∅	∅	pos

Advantages of MAT

- Higher flexibility
- More natural description
- Hierarchical description
- Figure-sub Figure relationship, Graphical Description

Properties of MAT

- same length, no junctions
- radius is constant
- only difference is course of axis
- for eg. worm

Prairie Fire Analogy

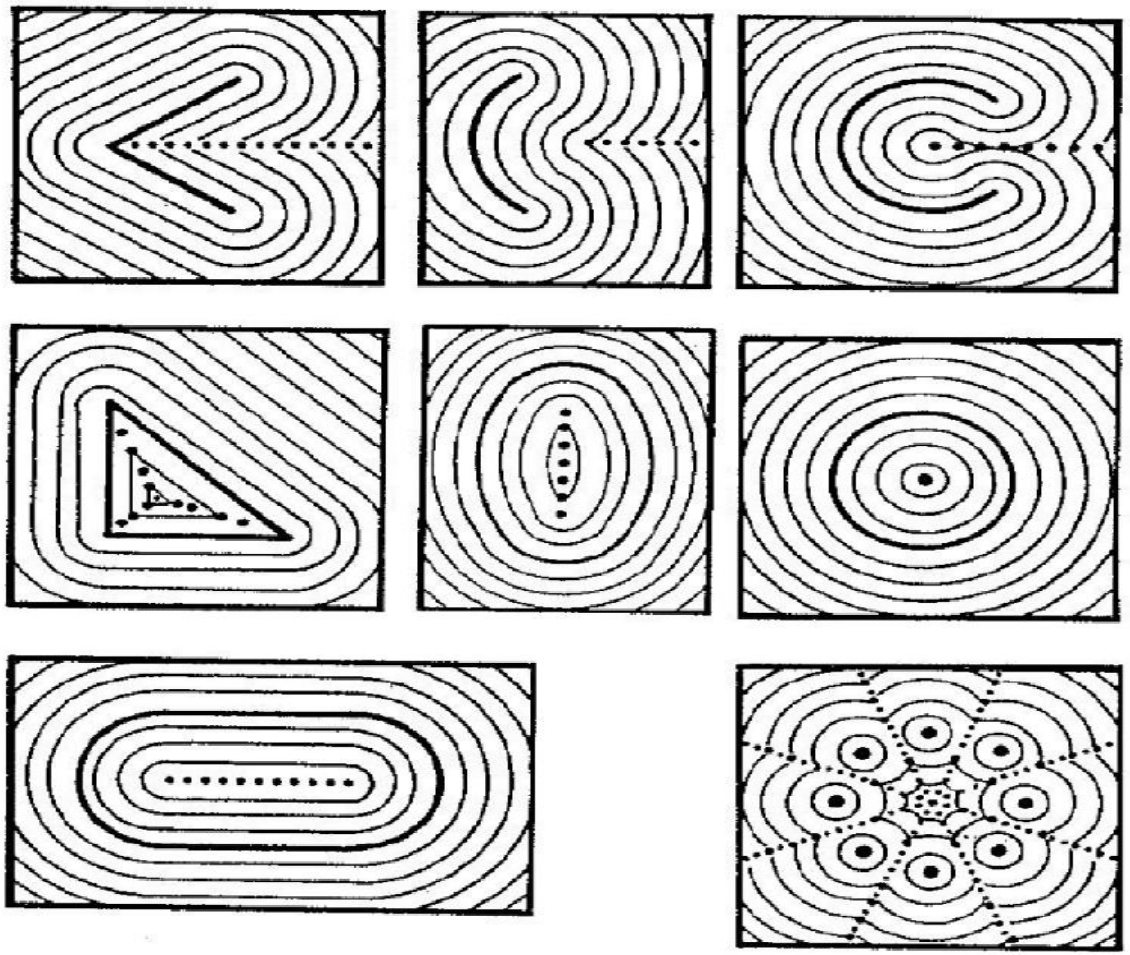


FIG. 8. A succession of grassfire wavefronts for some simple inputs. At the top, the grassfire is started along open contours. The sym-ax (shown dotted) occurs on the inside of the angle only, starting at the center of curvature and starting at a pinch in the space—ending at the center. The center panel shows some closed contours combining the above features. The sym-ax disappears at the largest inscribed circle. Note that the boundaries are convex and have no outside sym-ax. The bottom panel shows the sym-ax for a parallel boundary and for a set of points on a circle. In the parallel oval, the grassfire disappears all at once. The points on a circle give an example whereby the object is in the ground and discrete points can be treated as equivalent to a contour in generating an object.

- Propagation of fire fronts
- Begins at the boundary, constant speed
- Radius of curvature
- Circle : single point of symmetry
- Oval : SA with constant SD
- Dots arranged in circle :
- Symm Axis branches in the ground
- First row : open contours
- Second row : closed contours
- Third row : Parallel boundary, grassfire disappears all at once
- Triangle : 3 corners propagate, disappear at center of inscribed circle
- Ellipse : shortest to longest radius of curvatureSymmetry, acceleration

Alternative Description of Skeleton

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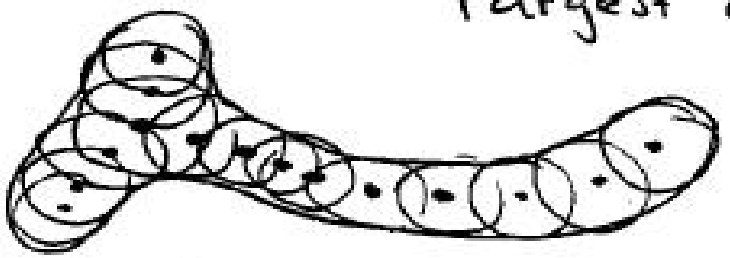
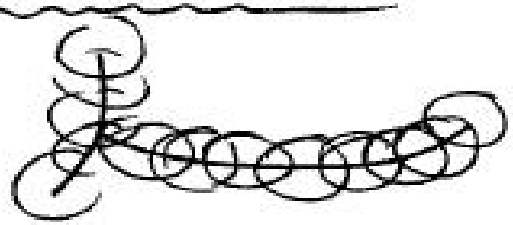
Geometrical description:

Skeleton: Locations of center points of all largest disks fully inside the object

(smaller disks fully covered by larger disks are removed!)



Reconstruction:



Superposition of all disks defined by the skeleton.

Disk: center & radius

SHAPE DESCRIPTION USING SAT's

CONDITIONS FOR SHAPES UNDER STUDY

1. Boundary has tangent and curvature everywhere except at finite no. of places
2. Boundary has a finite no. of connected pieces (infinite holes can't exist).

POINT TYPES

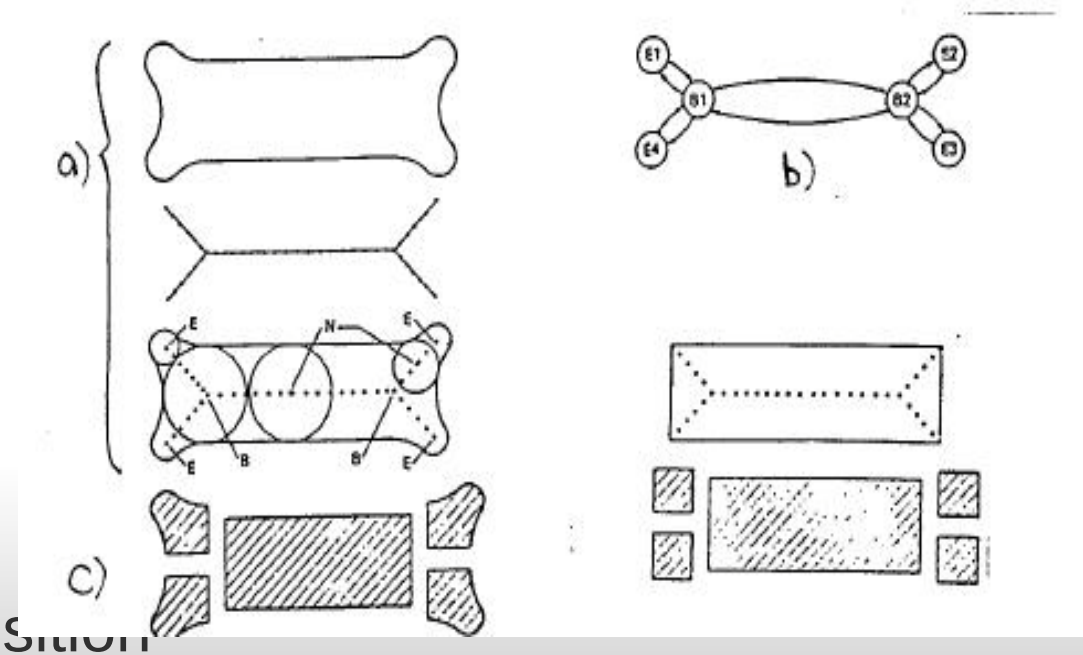
1. E - End Points,
2. N- Normal Points,
3. B- Branch points

SEGMENTATION

Simplified Segments

Intuitive for biological shapes

Divides on Boundary or knot



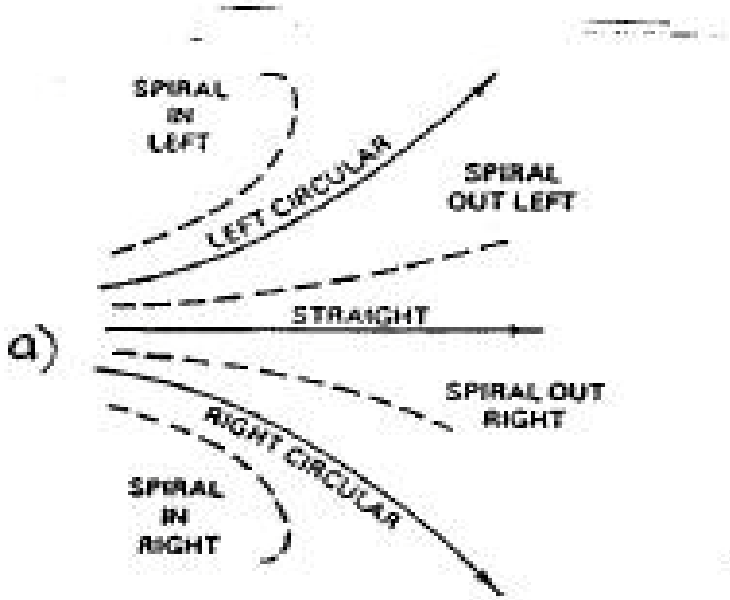
FIGURE

a) Elementary Shape Decomposition

b) Relational Graph Structure

c) Simplified segmentation

Elements of Shape



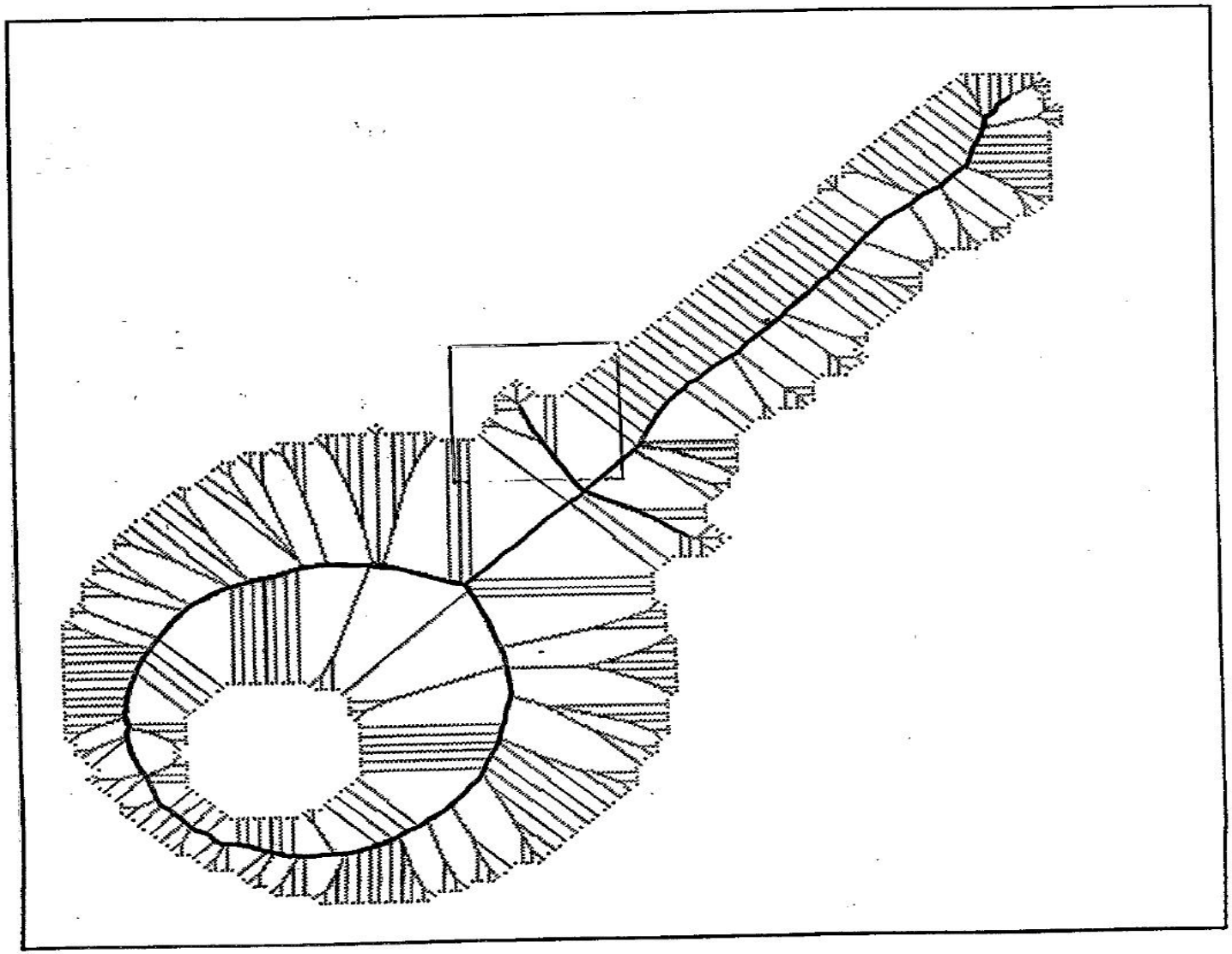
Axis curvature change (k_c)	Axis curvature (k_a): Pos	Zero	Neg
Pos	Spiral in left		Spiral out right
Zero	Circular left	Straight	Circular right
Neg	Spiral out left		Spiral in right

b)

Object Width = 2*radius
Object Opening = Triangle of tangents at touching points
Axis of Curvature
Object Curvature : Change in Object Angle along Axis
Elements of Shape Language
1. Axis of Curvature Change
2.Mathematical Characterization

KEY : VORONOI EXAMPLE

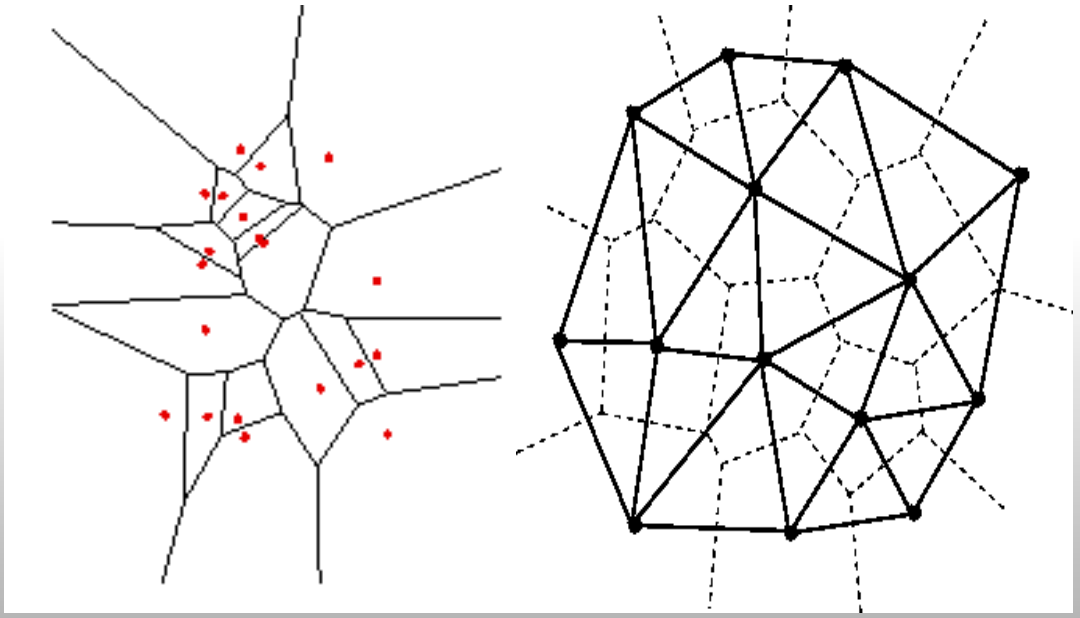
Voronoi-Diagramm des Objektinneren

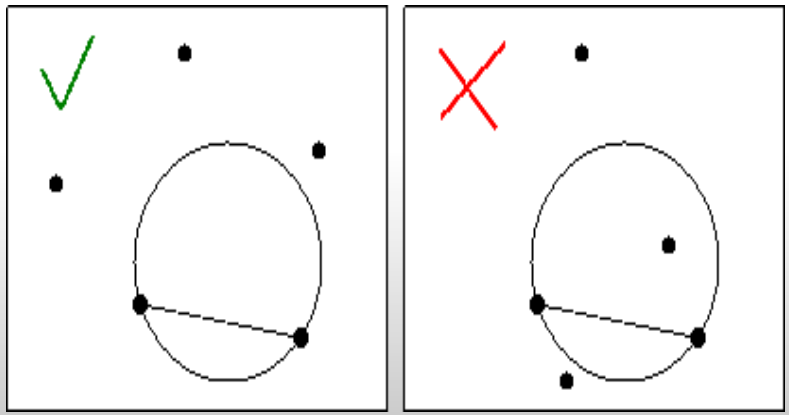


VORONOI DIAGRAMS

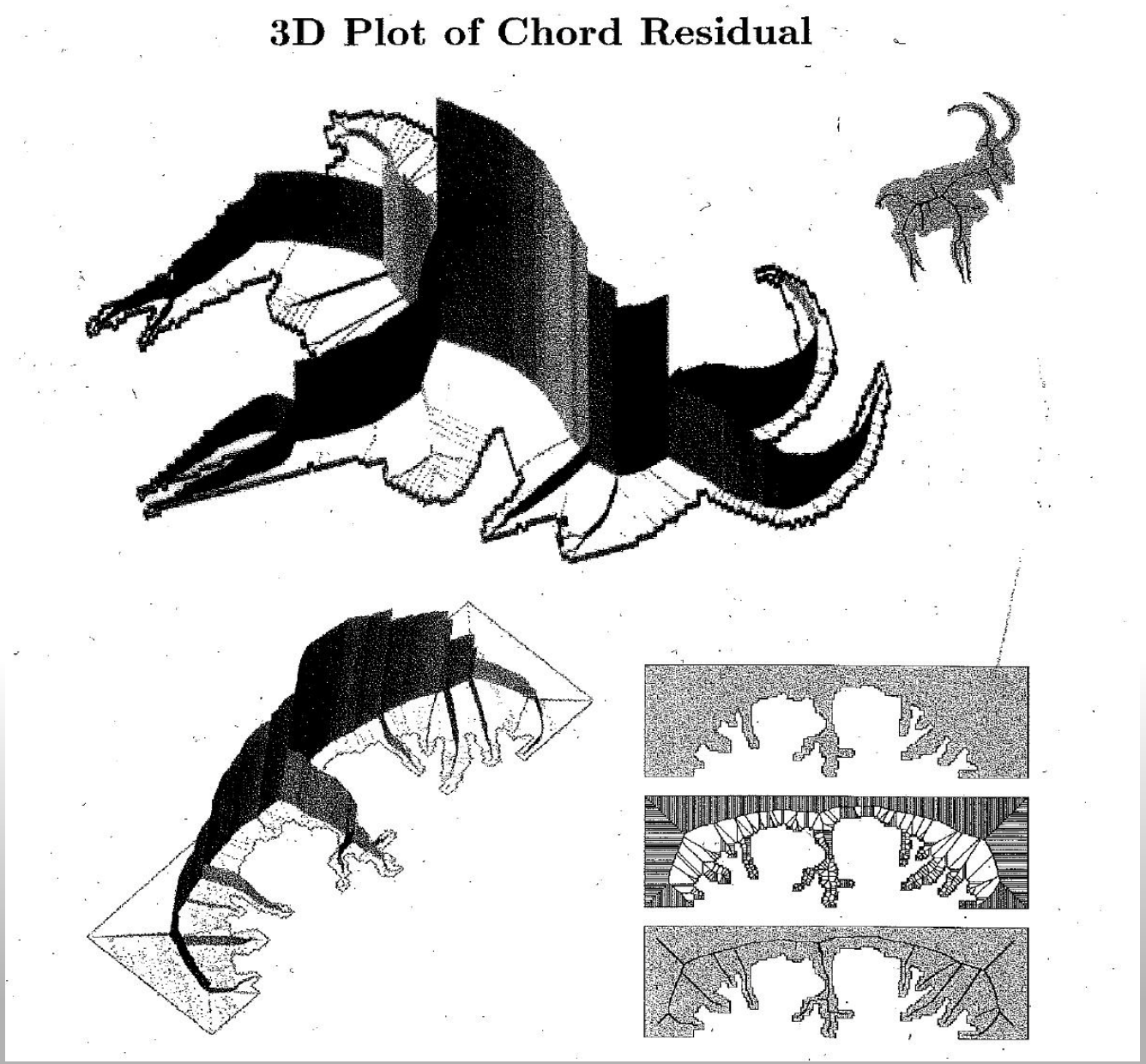
Voronoi Diagrams & Delaunay Triangulation

A Voronoi diagram is a geometric structure that represents proximity information about a set of points or objects. Given a set of sites or objects, the plane is partitioned by assigning to each point its nearest site. The points whose nearest site are not unique, form the Voronoi diagram. That is, the points on the Voronoi diagram are equidistant to two or more sites.
so for a set S of n sites:Voronoi diagram VD(S): the partition of the plane into blocks of points with the same nearest site or sites.





REGULARIZATION : Concept of Residuals



Types of Residuals

1. Potential
2.Circularity
3.Bi-Circularity
4.Chord

Example : Key

Example : Eliminate Lines from consecutive points

SKELETAL PYRAMID

Skeletons : ExoSkeleton and EndoSkeleton

Pruning of Skeletal Pyramid

1.Increasing the threshold without bound : branches are removed, other branches are also trimmed
2.Topological Hierarchy is computed

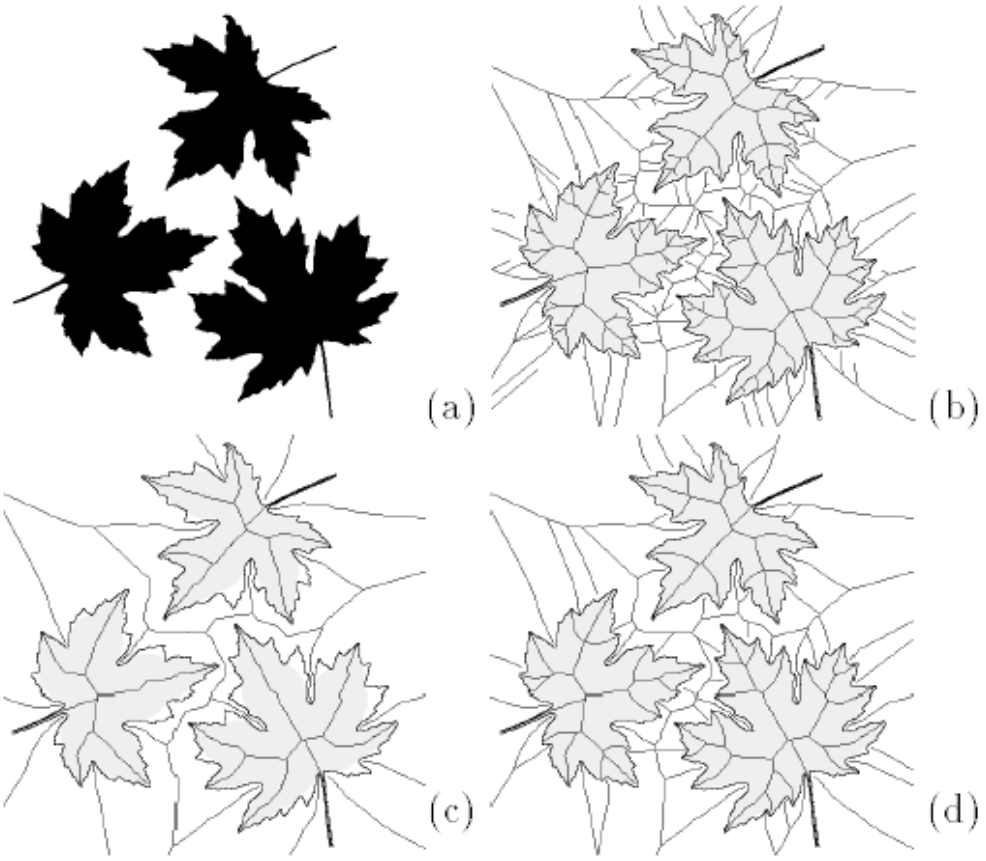


Figure 6: The Skeleton Pyramid: Two First Order VSK for Different Parameter Settings. (a) "maple leaves". (b) Voronoi skeletons, ΔR_C, $I = 3.0$. The complex boundary introduces numerous rather irrelevant branches. The shaded area (as in (c) and (d)) depicts the result of a vertex-based reconstruction of the shape, namely by drawing the largest inscribed disk at each vertex of the VSK. (c) The first order VSK of "maple leaf" shapes. Parameters $\tau_H = 0.10$, $\tau_C = 0.10$. (d) First order VSK with $\tau_H = 0.02$, $\tau_C = 0.10$.

Applications

1. Seperation of Overlapping objects : (bottleneck in VD)
- can be identified as local minima of disk radii along a branch.
2. Object Recognition : Fastest one at nodes,
others do contour matching, some weight with residual
3. Extraction of Line Graphs
4. Understanding of Road Maps