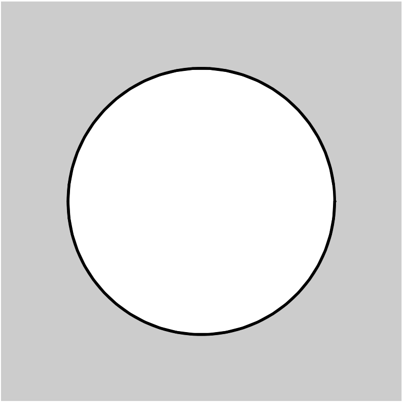
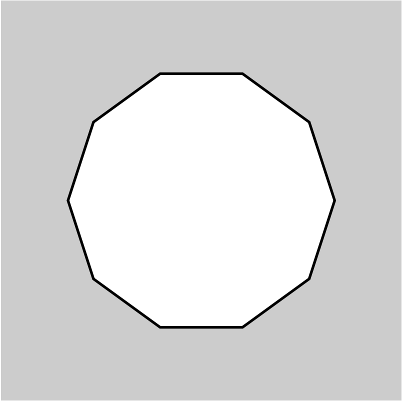
CMSC427
Points, polylines and polygons

Issue: discretization of continuous curve

- In theory, smooth curve:

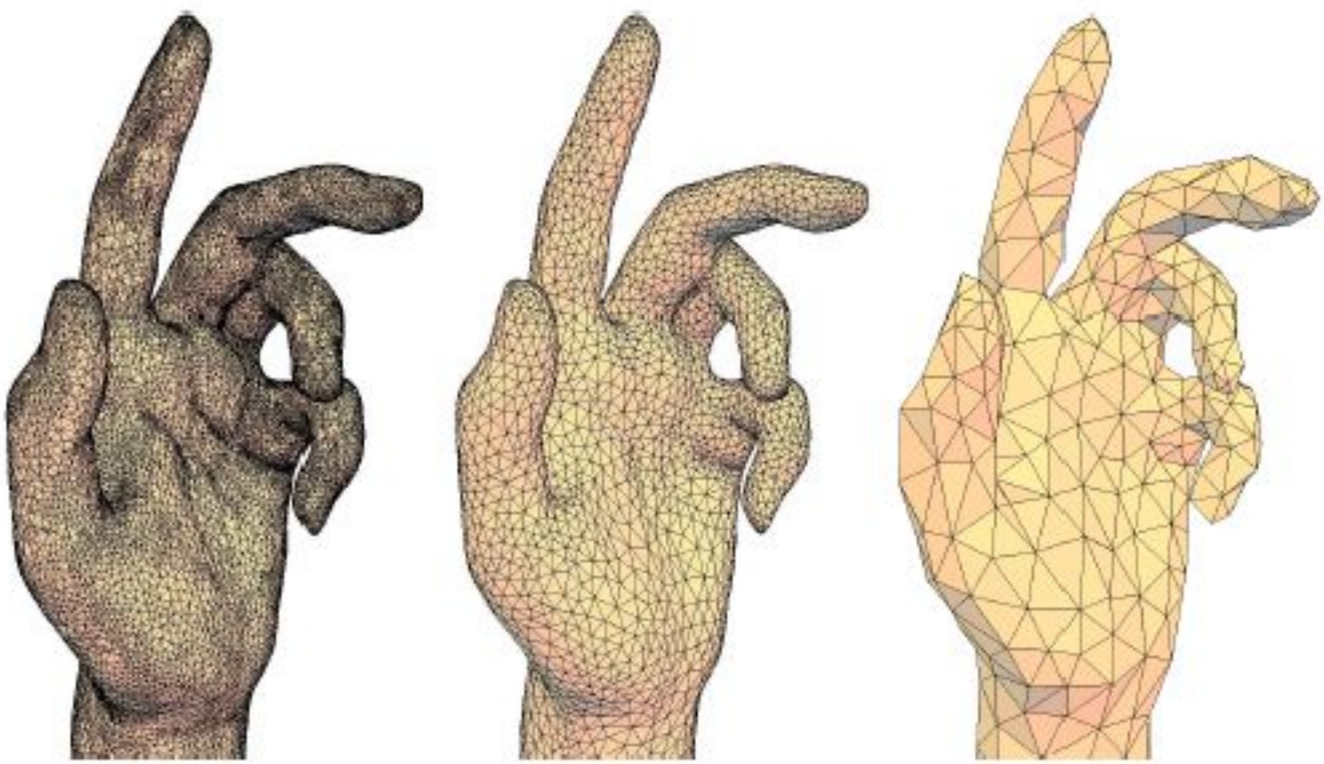


- In reality, piecewise discrete approximation:

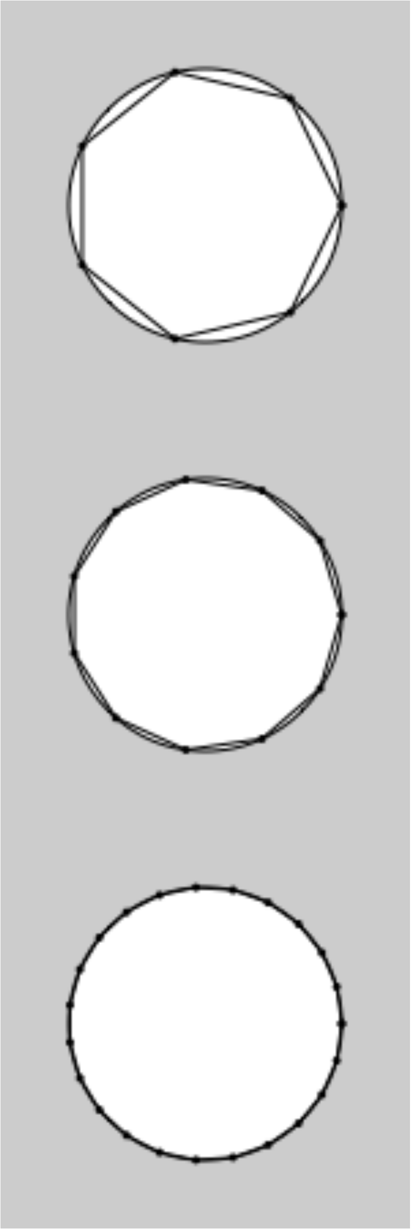


Modeling with discrete approximations

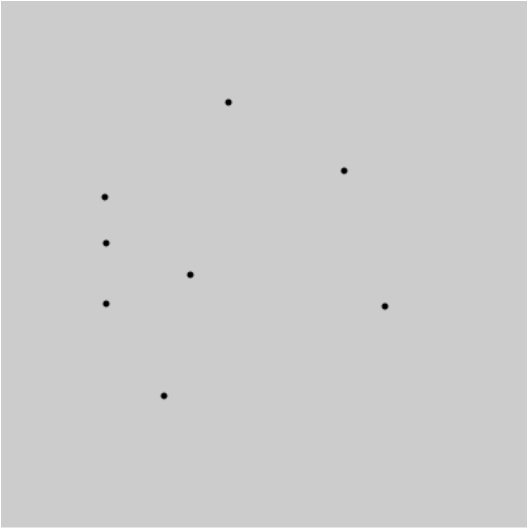
Increase fidelity with more points



(a) 25,000 vertices. (b) 5,000 vertices. (c) 500 vertices.

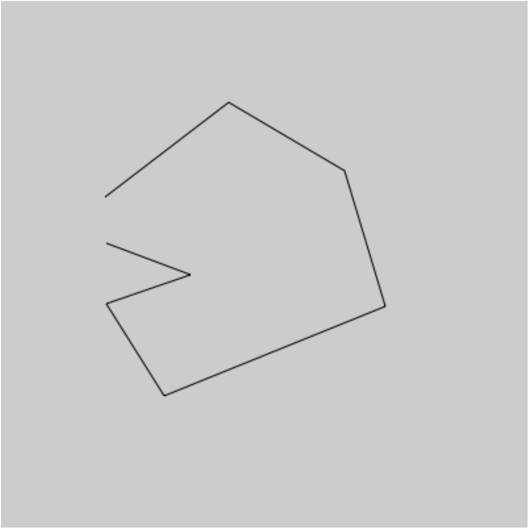


Points, polylines and polygons



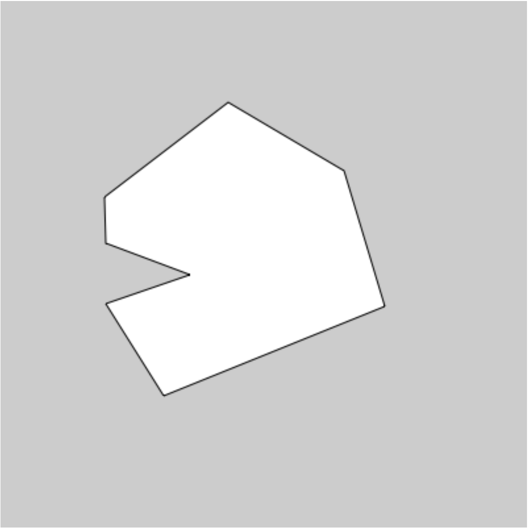
Points

Also called *vertices*



Polyline

Continuous sequence of line segments

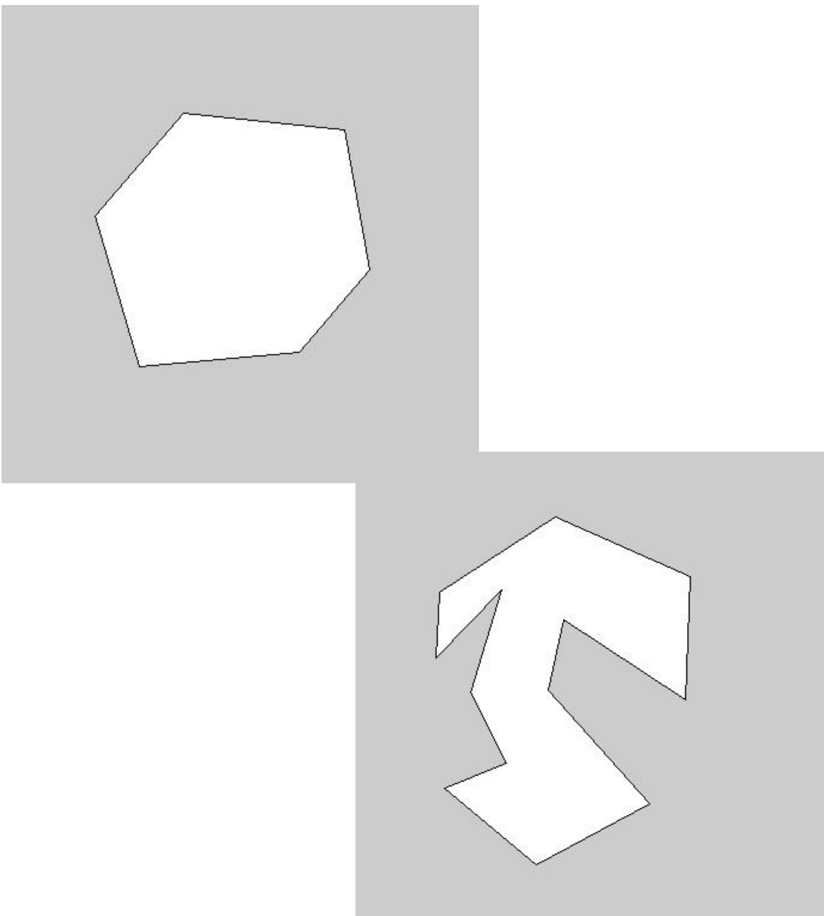


Polygon

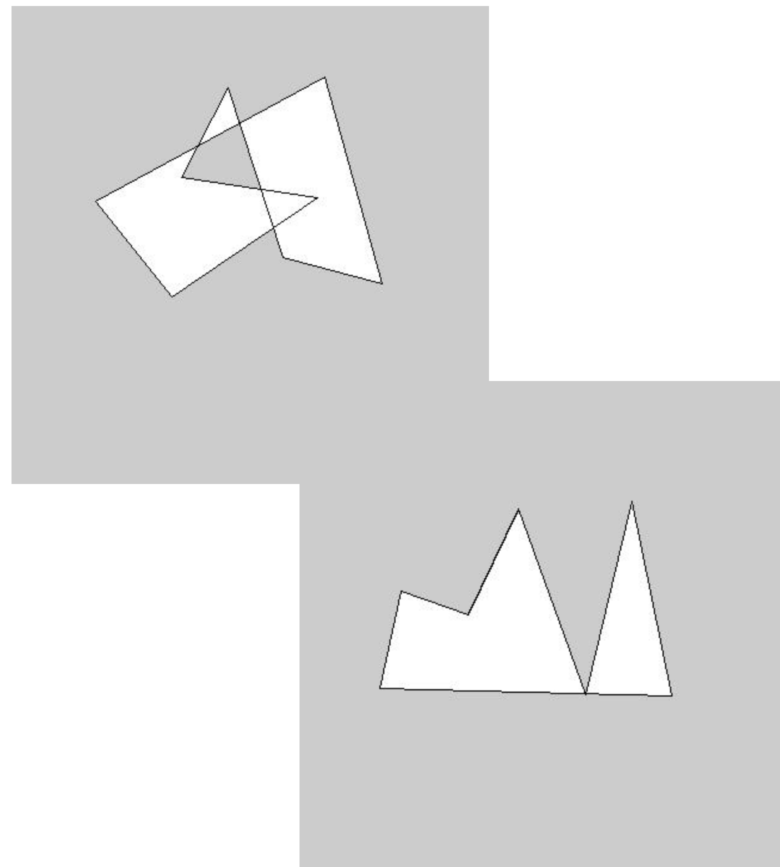
Closed sequence of line segments

Polygon properties I

- Simple
  no self-intersections
  no duplicate points

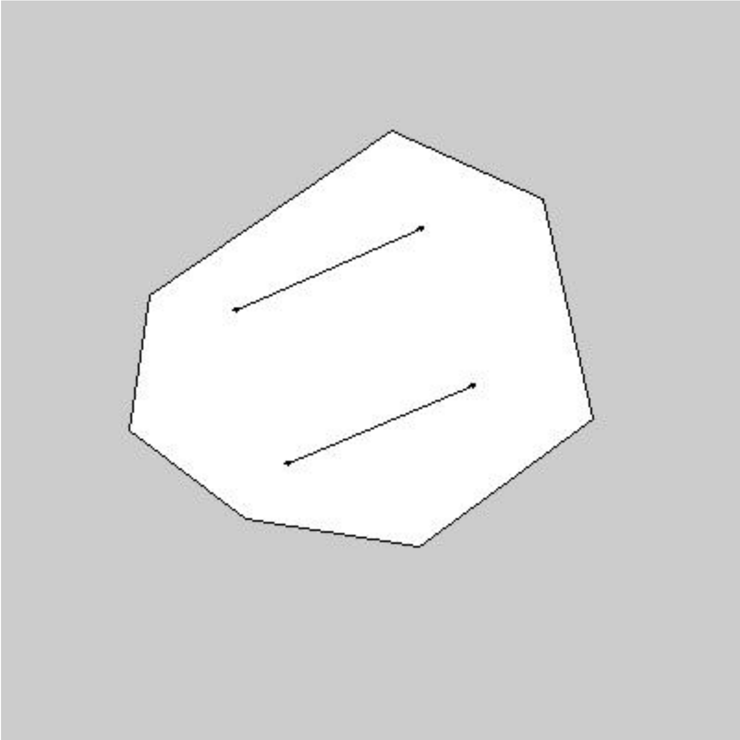


- Non-simple
  self-intersections
  duplicate points

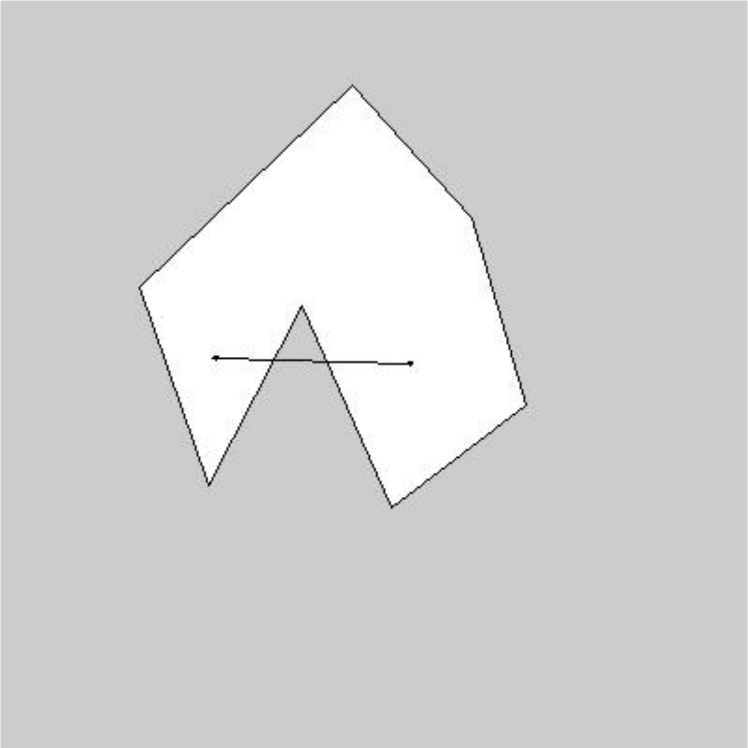


Polygon properties II

- Convex polygon
  Any two points in polygon can be connected by inside line



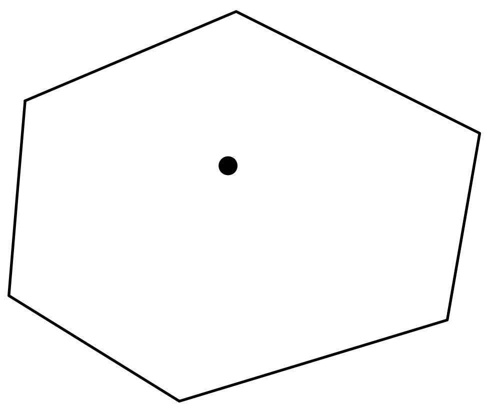
- Concave polygon
  Not true of all point pairs



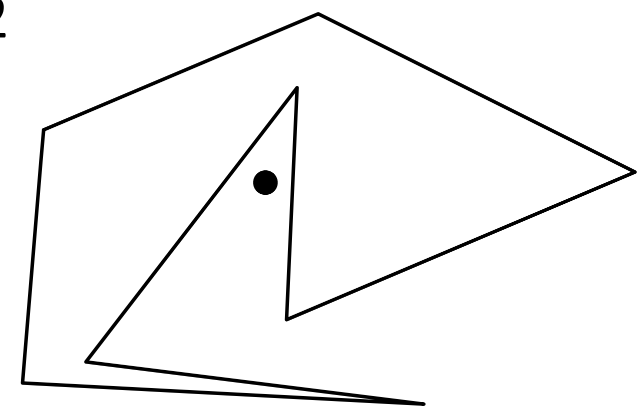
Point in polygon problem

Is P inside or outside the polygon?

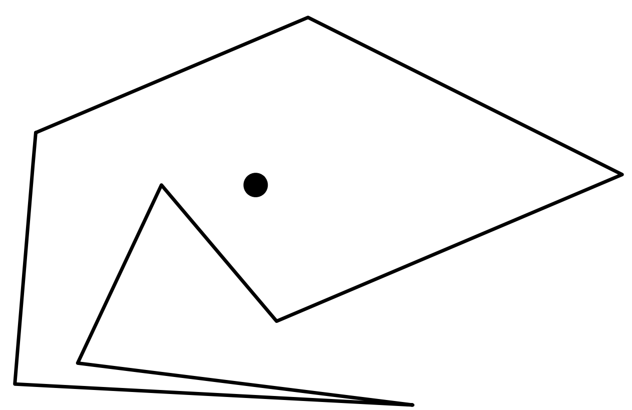
Case 1



Case 2

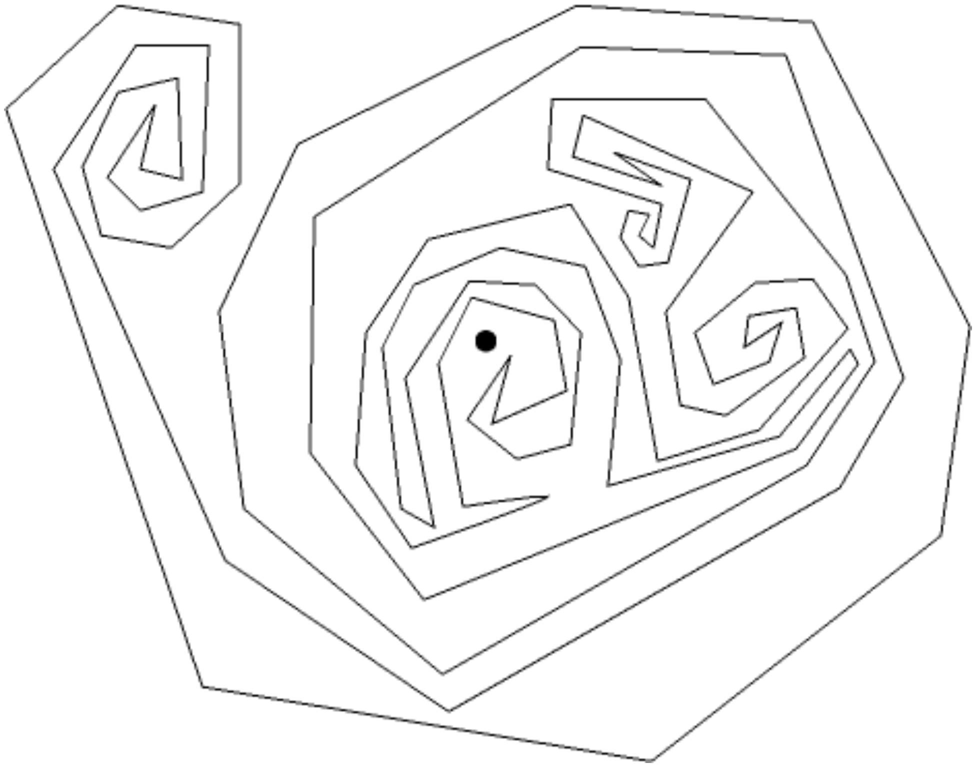


Case 3



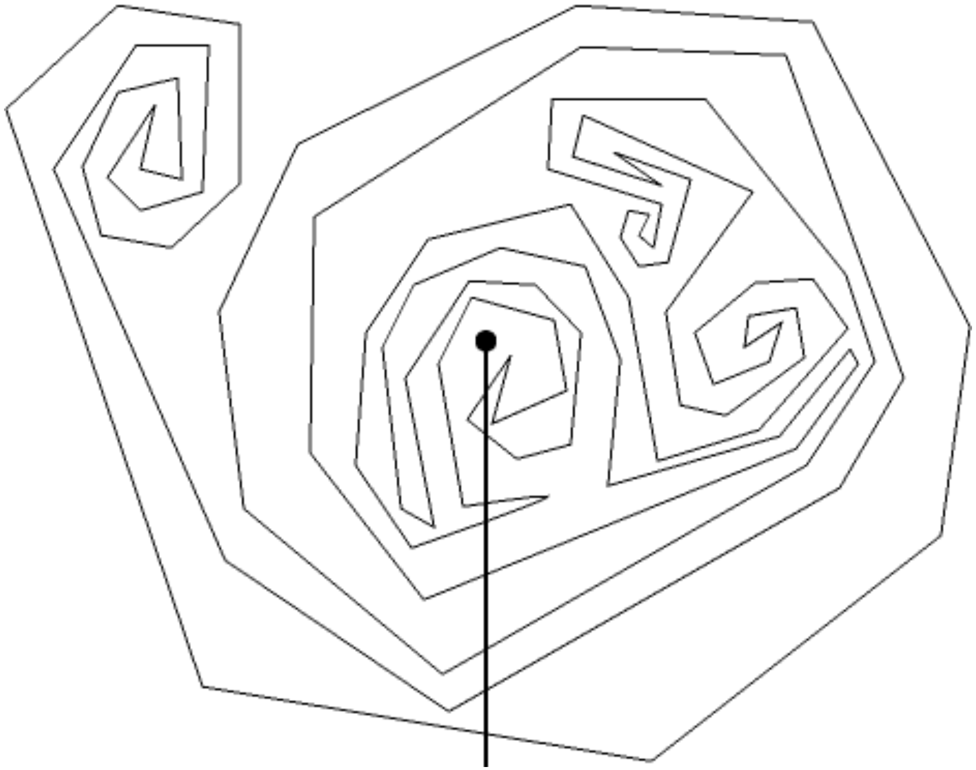
Point in polygon problem

Is P inside or outside the polygon?



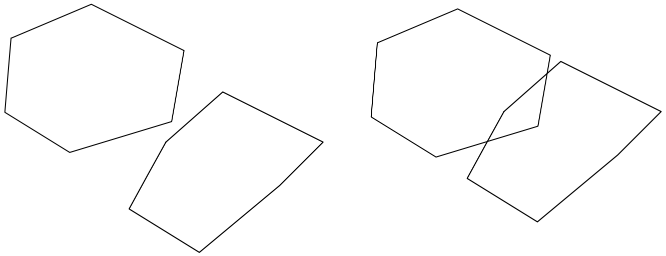
Point in polygon problem

Is P inside or outside the polygon?

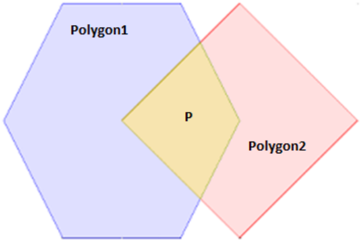


Other polygon problems

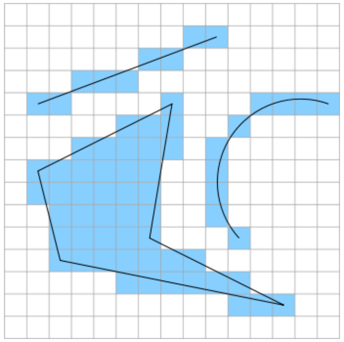
- Polygon collision
  - Return yes/no



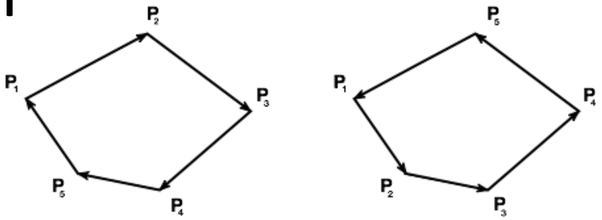
- Polygon intersection
  - Return polygon of intersection (P)



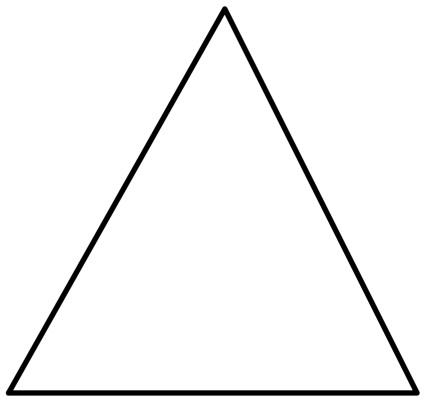
- Polygon rasterization
  - Return pixels that intersect



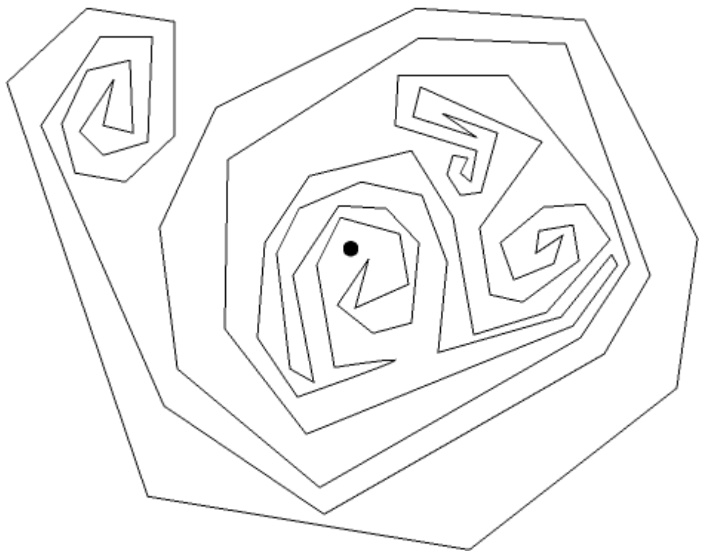
- Polygon winding direction
  - Return clockwise (CW) or counterclockwise (CCW)



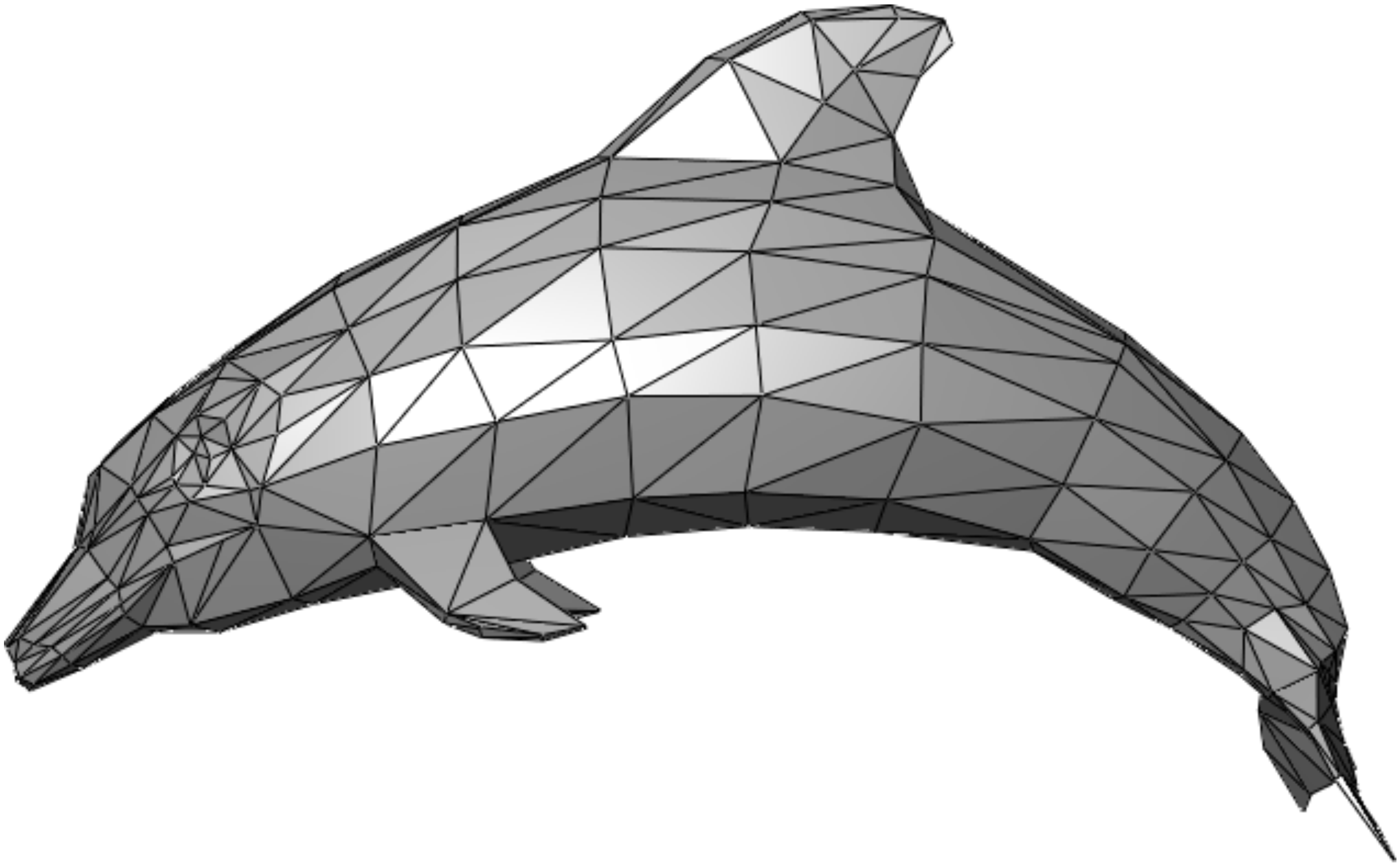
Moral: easier with simple, convex, low count polygons



Vs



Triangular mesh



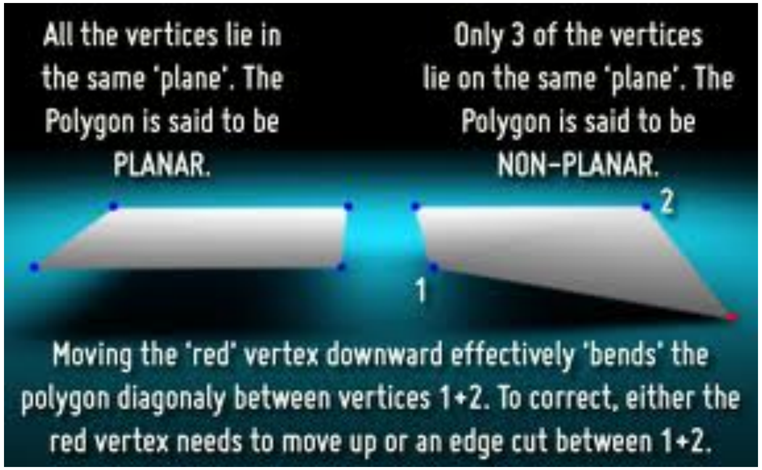
Why triangles …

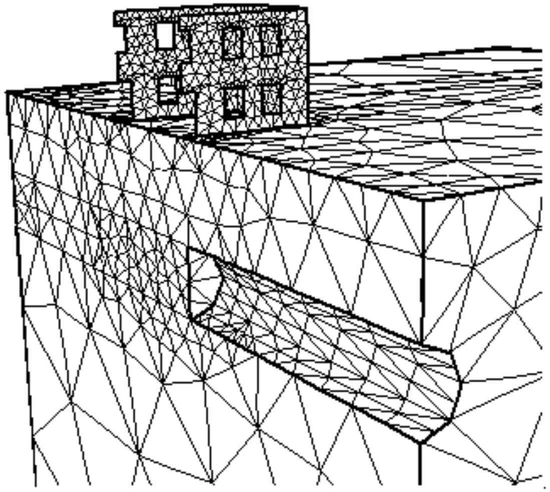
Why triangles?

1. Easiest polygon to rasterize

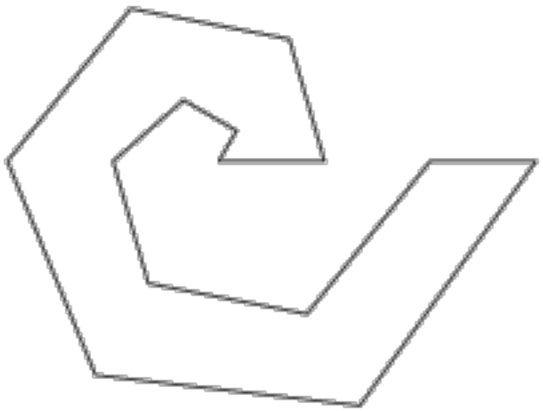
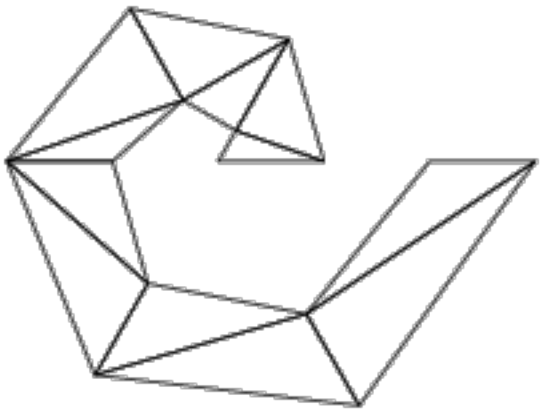
2. Polygons with n > 3 can be non-planar

3. Lighting computations in 3D happen at vertices - more vertices give smoother illumination effects





Polygon triangulation

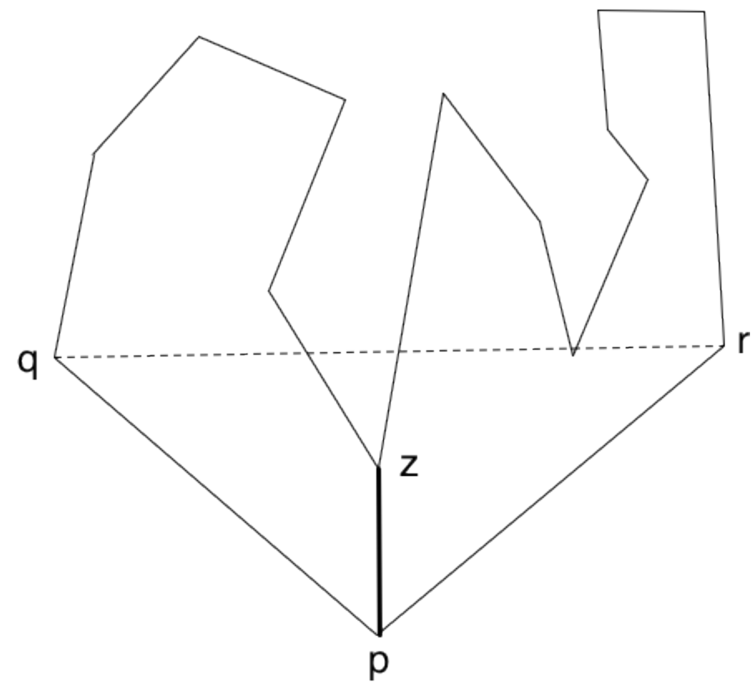



Theorem: Every simple polygon has a triangulation

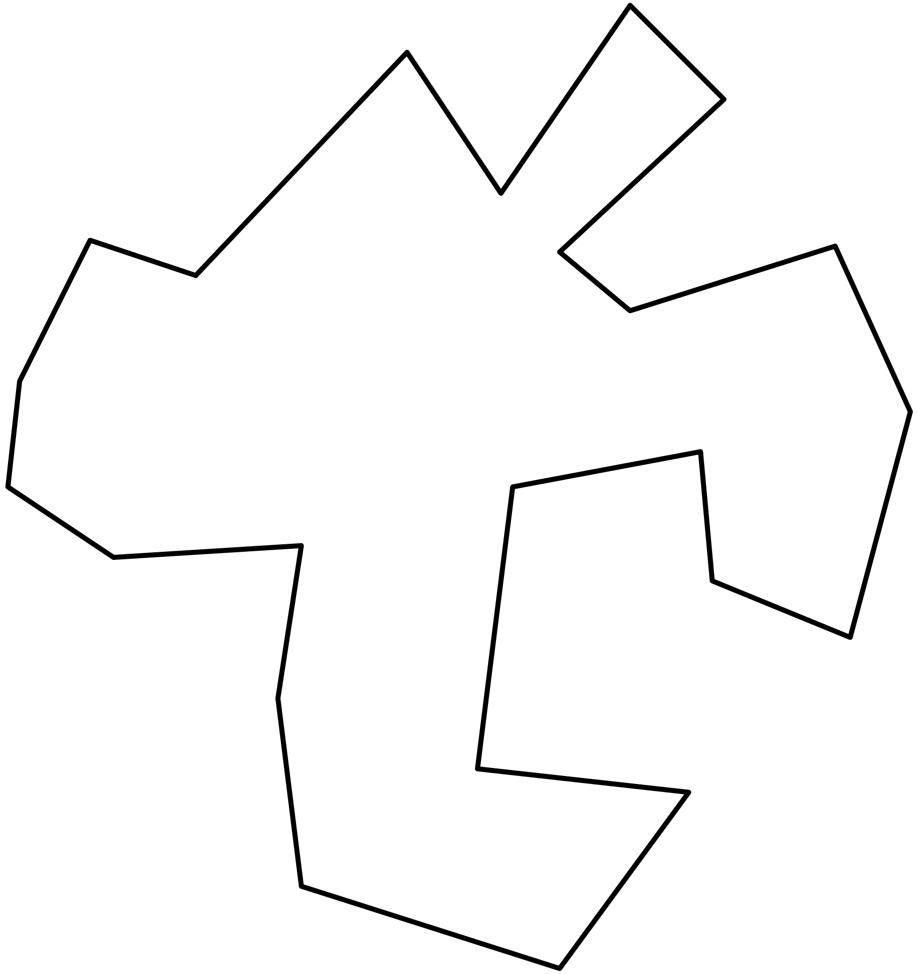
- Proof by induction

  Base case: n = 3

  Inductive case
  A) Pick a convex corner p. Let q and r be pred and succ vertices.
  B) If qr a diagonal, add it. By induction, the smaller polygon has a triangulation.
  C) If qr not a diagonal, let z be the reflex vertex farthest to qr inside $\triangle$pqr.
  D) Add diagonal pz; subpolygons on both sides have triangulations.

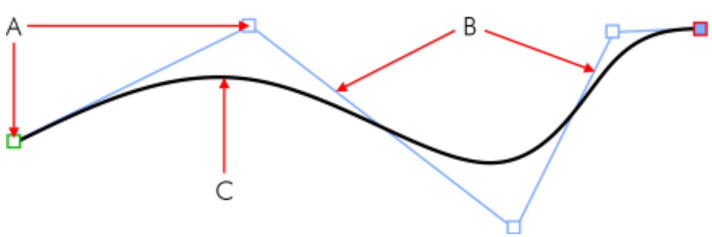


Example: cutting off ears



Parametric curves vs. polylines

- Parametric curves
  1. Model objects by equation
  2. Complex shapes from few values
  3. Modeling arbitrary shape can be hard
- Polylines
  1. Model objects by data points
  2. Complex shapes need additional data
  3. Can model any shape approximately
- Looking forward
  - Use polylines to control general parametric curves
  - B-splines, NURBS



What you should know after today

1. Definitions of polyline and polygons
2. Definitions of properties of polygons (simple, convex/concave
3. Point in polygon problem and first solution
4. That polygons support interesting problems (Don't have to know them now)
5. Why we like triangles over more complex polygons
6. That simple polygons can be triangulated