Filling Polygons

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Map of the lecture

- Filling rectangles
  - algorithm
  - problems and solutions
- Filling polygons:
  - algorithm
  - problems and solutions
  - algorithm details: active-edge table

Filling rectangles

- Rectangle defined by: (xmin,xmax)x(ymin,ymax)
- Fill it using scan-line algorithm:

```
for y = ymin to ymax
   for x = xmin to xmax
      LightPixel(x,y)
   end_for
end_for
```

Problems and solutions

- Two rectangles sharing an edge:
  – the edge will be drawn twice
- Solution: revised algorithm

```
for y = ymin to ymax-1
   for x = xmin to xmax-1
      LightPixel(x,y)
   end_for
end_for
```

- Only draw if it’s below or on the left

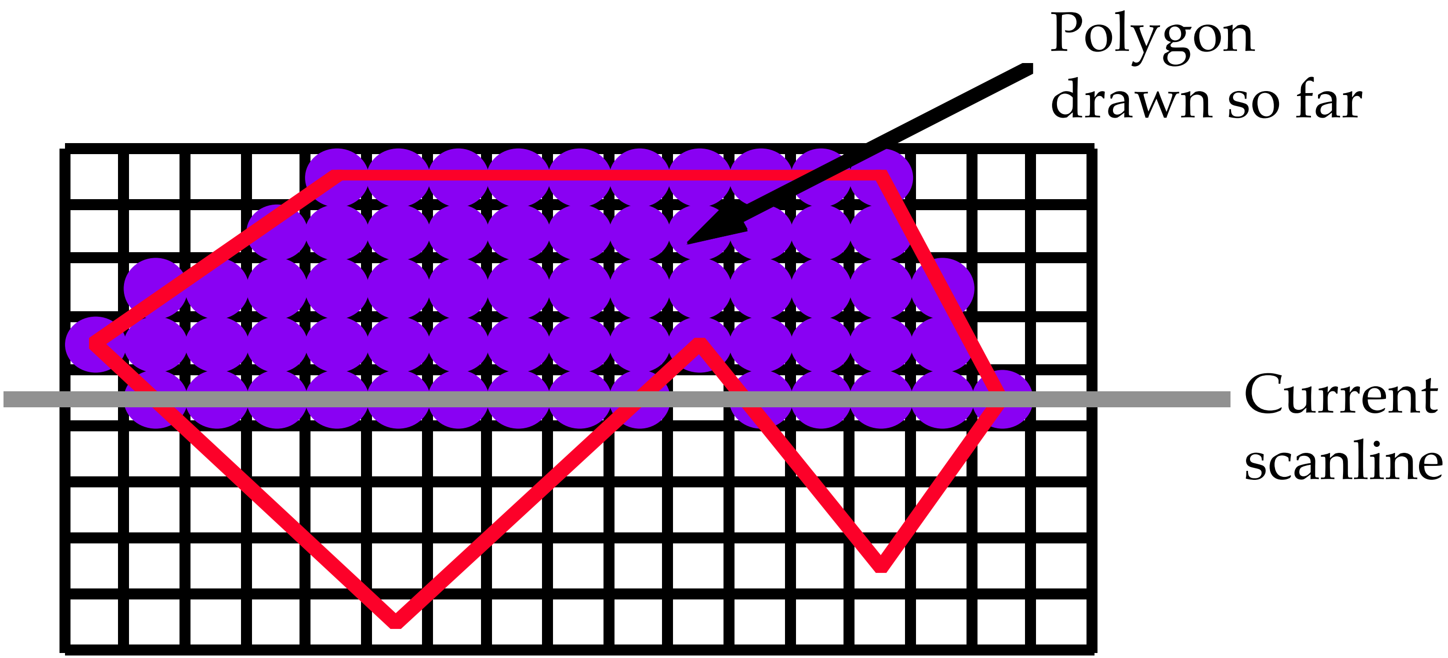
Filling Polygons

- Main algorithm:

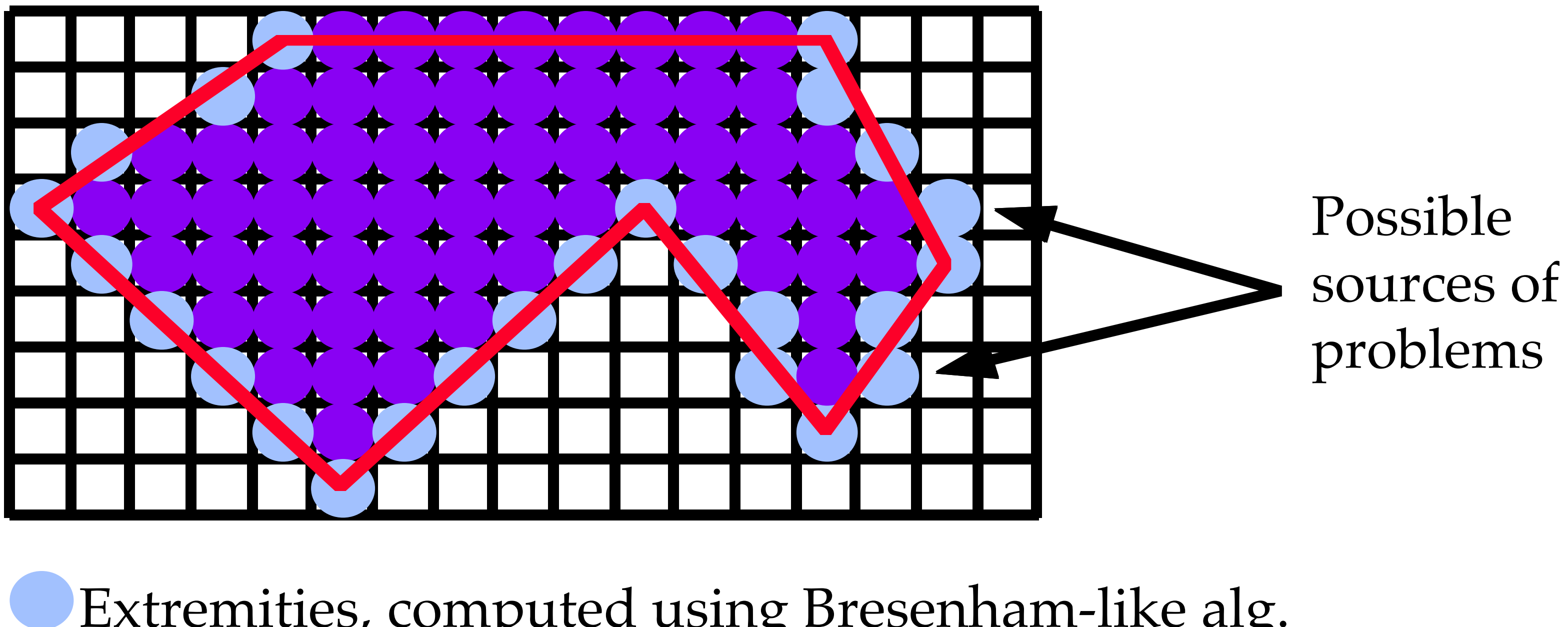
```
for y = 0 to height_screen
    find intersection polygon/scanline
    fill the intersection
end_for
```

- Intersection polygon-scanline:
  - the algorithm in a moment
  - the specifications now

Filling Polygons: example



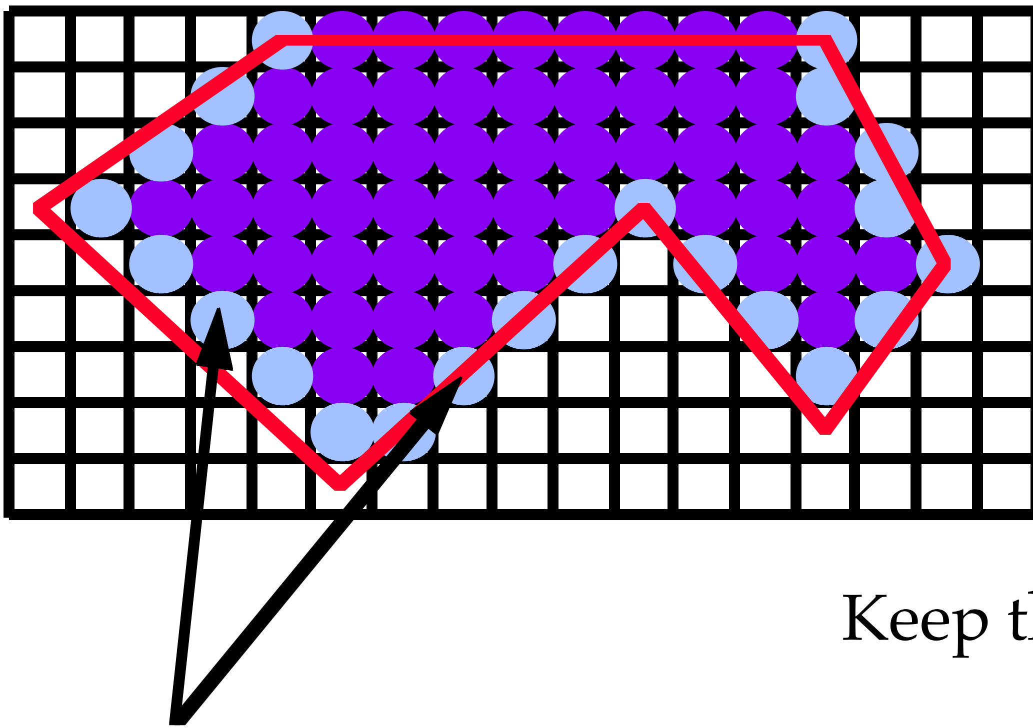
Filling Polygons: example (2)



Extremities, computed using Bresenham-like alg.

- What happens with two neighbouring polygons?

Filling Polygons: example (3)



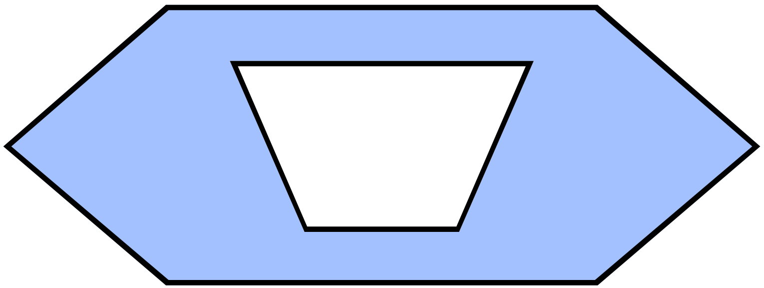
Keep the extremities inside

Integer intersections: do as we did with rectangles

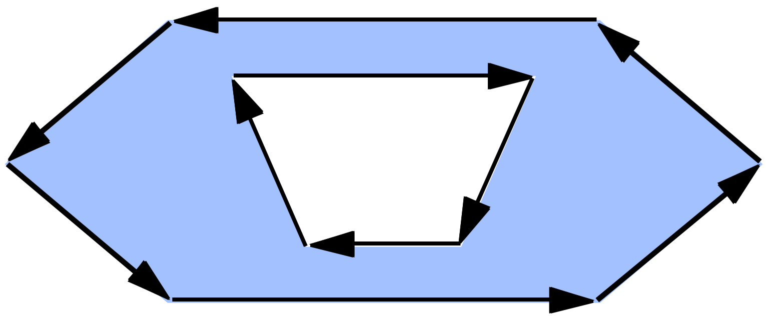
Filling Polygons: inside/outside

- Even/odd:
  - for each scanline, count number of edges encountered so far:
    - even: outside
    - odd: inside
- Edge orientation:
  - the edge is oriented, so is the scanline
  - scanline entering: add one to the counter
  - scaline leaving: remove one

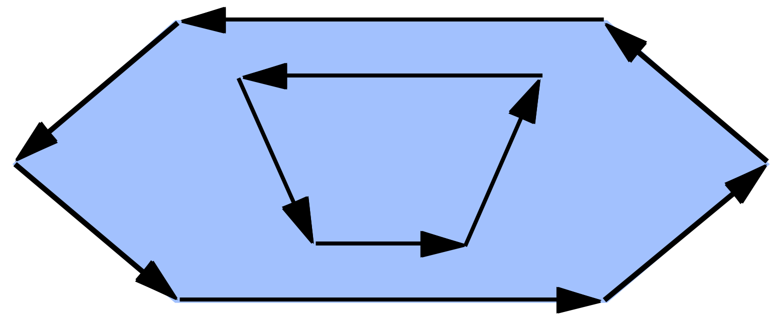
Inside/outside: example



Even/Odd



Edge orientation (1)



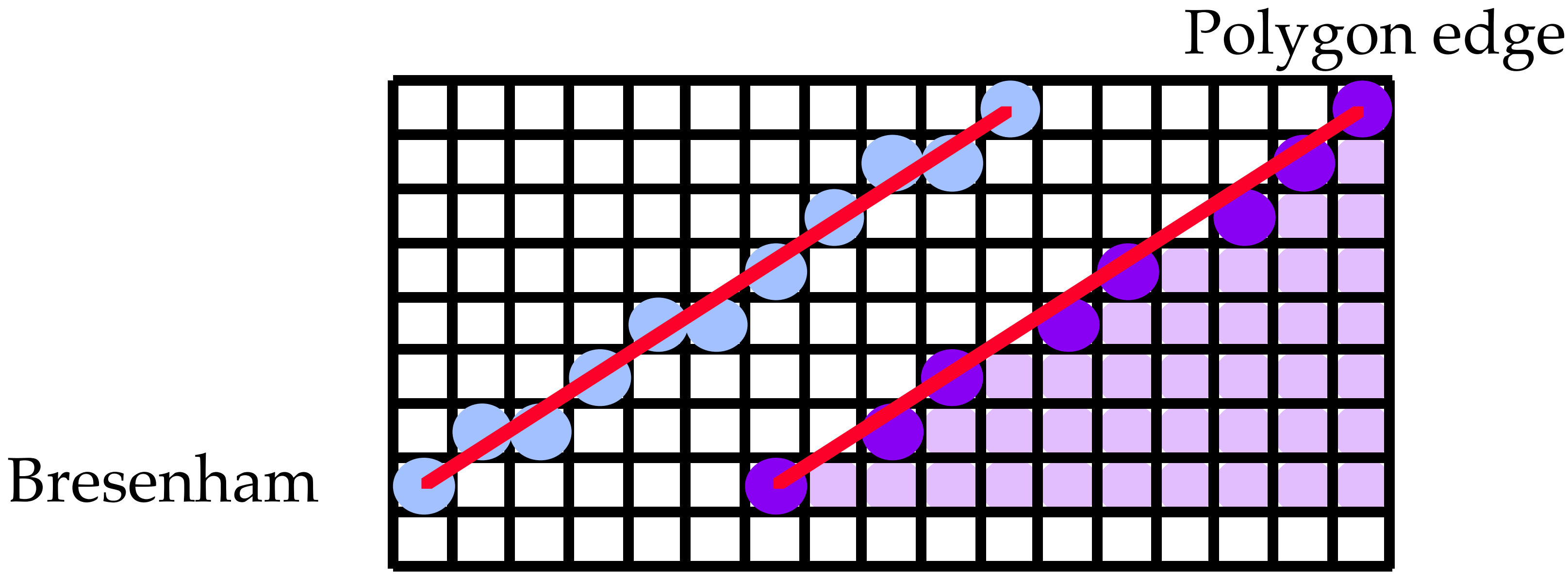
Edge orientation (2)

Computing the extremities

- Scanline-edge intersection:
  - not exactly Bresenham algorithm
  - requirements are more relaxed
- Active-edge table:
  - list of edges
  - ordered for maximum efficiency

We don’t need Bresenham

- Something simpler may suffice:



Scanline-edge intersection

- Moving from one scanline to the next:

  $x \mathrel{+}= 1/m$

  - with m, the slope of the edge:

    $m = (y_{\max}\text{-}y_{\min})/(x_{\max}\text{-}x_{\min})$

  - therefore, x can always be expressed as:

    $x = a + b/(y_{\max}\text{-}y_{\min})$

    (a and b are integers)

Scanline-edge intersection (2)

- Keep x as two integers (a,b)
- moving to the next scanline:

writePixel(a,y)

b += $(x_{\text{max}}-x_{\text{min}})$

while (b >= $(y_{\text{max}}-y_{\text{min}})$) {

  b -= $y_{\text{max}}-y_{\text{min}}$

  a ++

}

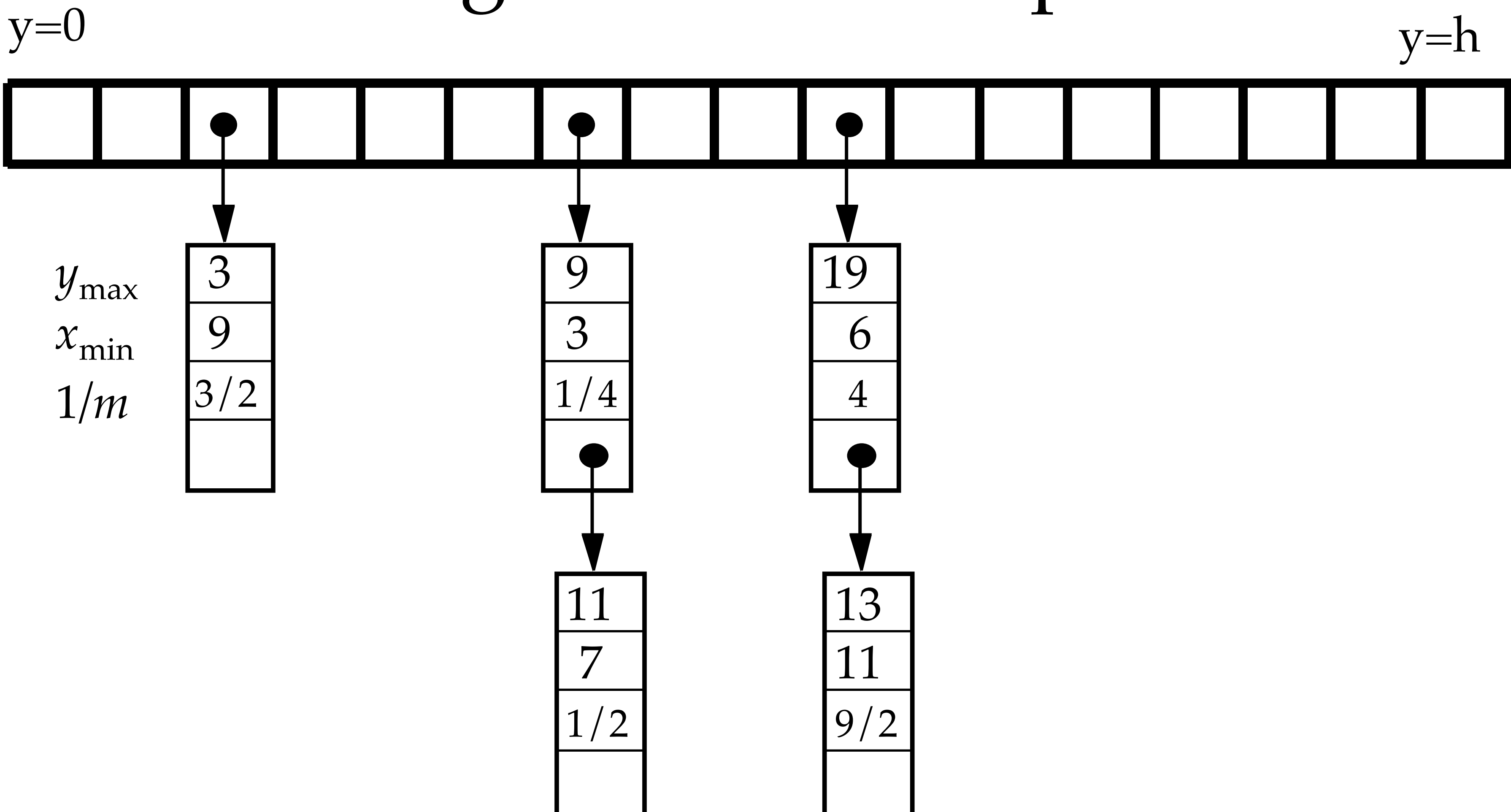
Scanline-edge intersection (3)

- Rounding-up:
  - avoid lighting exterior pixels
  - draw pixel (a,y) if it is a right-edge
  - draw pixel (a+1,y) if it is a left-edge

Edge Table

- Keep bucket list of all edges
  - one bucket per scanline
- Edges inserted at bucket of their $y_{\min}$
- Within a bucket:
  - sorted by order of x coordinate at $y_{\min}$
- Entries contain:
  - $y_{\max}$, x value at $y_{\min}$, and $1/m$

Edge Table: example



Active Edge Table

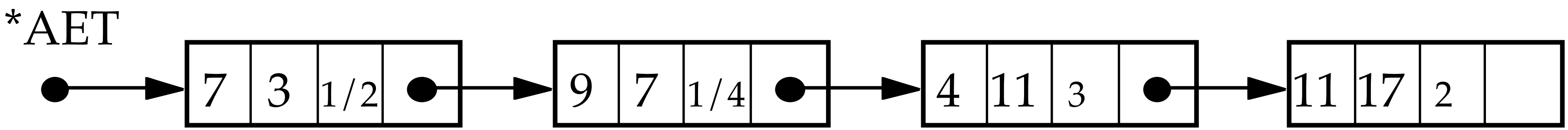
- Keep list of edges that are intersected by the scanline
- Use Edge Table
- Update at each scanline
- Start with y at smallest non-empty bucket
- Initialize AET to be empty

Active Edge Table (2)

- For each y value:
  - move bucket y content from ET to AET
  - sort AET on x values
  - fill in desired pixels on the scanline using AET
  - remove from AET edges with $y_{max}=y$
  - for each edge in the AET, update x for the next scanline

Active Edge Table: example

- Sample AET:



- Draw from 3 to 7, then 11 to 17

Drawing polygons: summary

- A simple algorithm — in theory
- Difficult to implement, in practice
- Everything is in the data structure
  - ET
  - AET
- Cornerstone for other algorithms:
  - visible-surface determination
  - shading (Gouraud shading, Phong shading)

Special case: triangles

- In a triangle, there are only two edges on a given scanline
- Simpler to draw:
  - no need for ET/AET
- Some softwares prefer to cut into triangles, then fill those triangles:
  - easier for hardware and assembly
  - efficiency linked to number of triangles