Computer Graphics

Lecture-03
Scan Conversion

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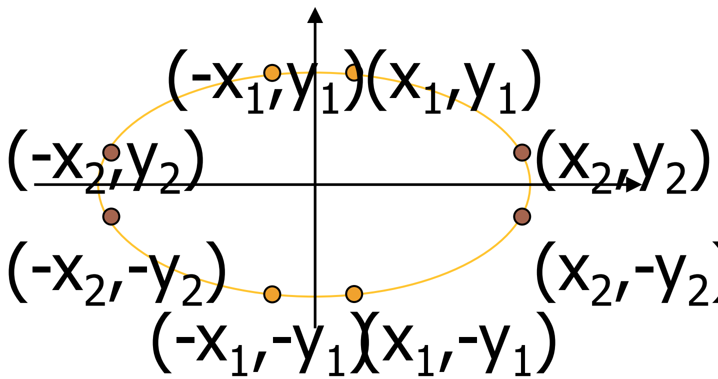
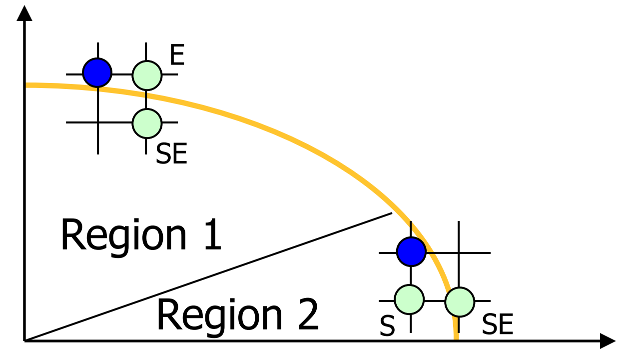
Midpoint Ellipse Algorithm

- Implicit equation is:

  $$F(x,y) = b^2x^2 + a^2y^2 - a^2b^2 = 0$$

- We have only 4-way symmetry
- There exists two regions
  - In **Region 1** dx > dy
    - Increase x at each step
    - y may decrease
  - In **Region 2** dx < dy
    - Decrease y at each step
    - x may increase





Midpoint Ellipse Algorithm

Decision Parameter (Region 1)

Midpoint of the vertical line connecting E and SE is used to define the following decision parameter:

$$d_i = F(x_i + 1, y_i - \tfrac{1}{2})$$

$$= b^2(x_i + 1)^2 + a^2(y_i - \tfrac{1}{2})^2 - a^2b^2$$

$$\text{if } d_i < 0 \text{ then move to E}; (\mathrm{x}_{\mathrm{i+1}}, \mathrm{y}_{\mathrm{i+1}}) = (\mathrm{x}_\mathrm{i}+1, y_i)$$

$$d_{i+1} = F(x_i + 2, y_i - \tfrac{1}{2})$$

$$= b^2(x_i + 2)^2 + a^2(y_i - \tfrac{1}{2})^2 - a^2b^2$$

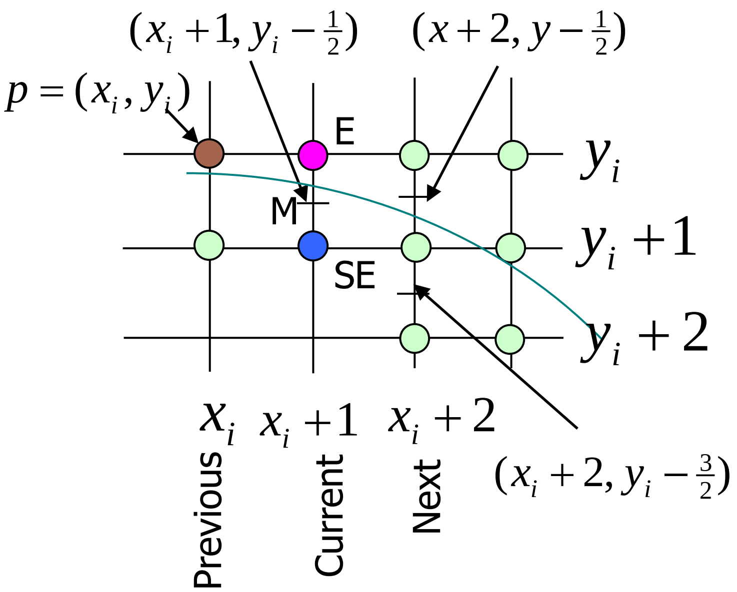
$$d_{i+1} = d_i + b^2(2x_i + 3)$$

$$\text{if } d > 0 \text{ then move to SE}$$

$$d_{i+1} = F(x_i + 2, y_i - \tfrac{3}{2})$$

$$= b^2(x_i + 2) + a^2(y_i - \tfrac{3}{2}) - a^2b^2$$

$$d_i = d_i + b^2(2x_i + 3) + a^2(-2y_i + 2)$$



Initial value with (0,b)

$$p_1 = b^2 + a^2(b - \frac{1}{2})^2 - a^2b^2 = b^2 - a^2b + a^2/4$$

Midpoint Ellipse Algorithm

Decision Parameter (Region 2)

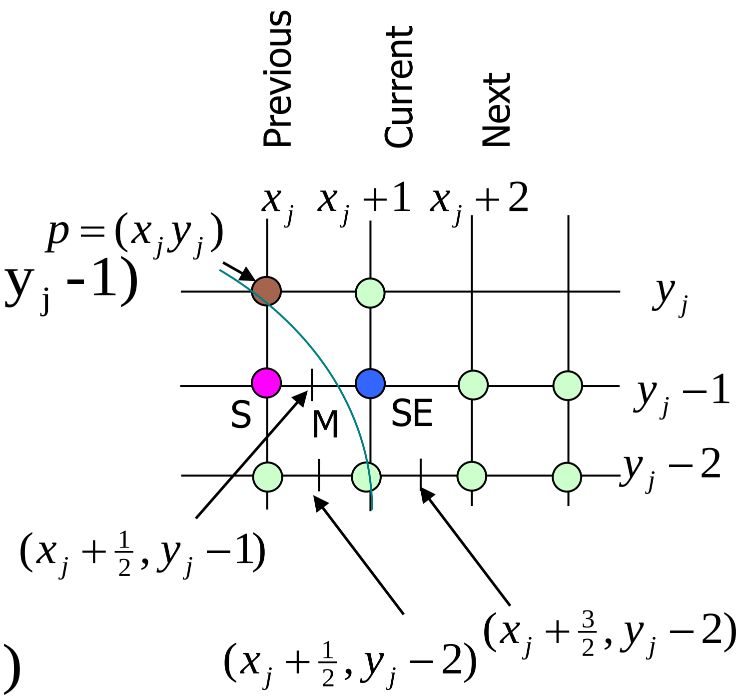
$$d_j = F(x_j + \tfrac{1}{2}, y_j - 1)$$
$$= b^2(x_j + \tfrac{1}{2})^2 + a^2(y_j - 1)^2 - a^2b^2$$

if $d_j < 0$ then move to $\mathrm{SE}(x_{j+1}, y_{j+1}) = (x_j + 1, y_j - 1)$

$$d_{j+1} = F(x_j + \tfrac{3}{2}, y_j - 2)$$
$$= b^2(x_j + \tfrac{3}{2})^2 + a^2(y_j - 2)^2 - a^2b^2$$
$$d_{j+1} = d_j + b^2(2x_j + 2) + a^2(-2y_j + 3)$$

if $d_j > 0$ then move to $\mathrm{S}(x_{j+1}, y_{j+1}) = (x_j, y_j - 1)$

$$d_{j+1} = F(x_j + \tfrac{1}{2}, y_j - 2)$$
$$= b^2(x_j + \tfrac{1}{2})^2 + a^2(y_j - 2)^2 - a^2b^2$$
$$d_{j+1} = d_j - a^2(2y_j + 3)$$



Self Study

- Pseudo code for midpoint ellipse algorithm
- Solved Problems:

  3.1,3.2,3.6,3.7,3.10,3.11,3.12,3.20,3.21

Side Effects of Scan Conversion

In computer graphics, a **raster graphics** image, or **bitmap**, is a dot matrix data structure representing a rectangular grid of pixels, or points of color, viewable via a monitor, paper, or other display medium

The most common side effects when working with raster devices are:

1. Aliasing
2. Unequal intensity
3. Overstrike

1. Aliasing

Jagged appearance of curves or diagonal lines on a display screen, which is caused by low screen resolution.

Refers to the plotting of a point in a location other than its true location in order to fit the point into the raster.

Consider equation y = mx + b
For m = 0.5, b = 1 and x = 3 : y = 2.5

So the point (3,2.5) is plotted at alias location (3,3)

Remedy

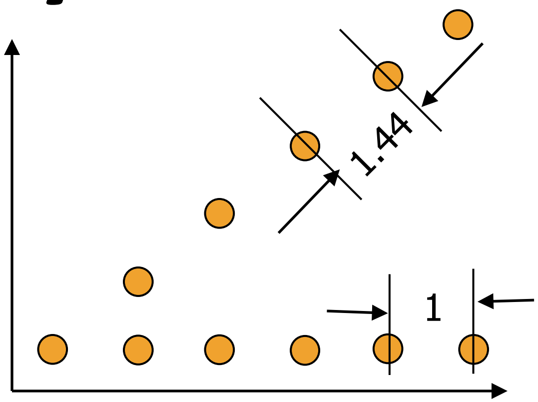
Apply anti-aliasing algorithms. Most of these algorithms introduce extra pixels and pixels are intensified proportional to the area of that pixel covered by the object.

2. Unequal Intensity

Human perception of light is dependent on

- ➢ Density and
- ➢ Intensity

of light source.



Thus, on a raster display with perfect squareness, a diagonal line of pixels will appear dimmer that a horizontal or vertical line.

Remedy

1. By increasing the number of pixels on diagonal lines.

3. Overstrike

The same pixel is written more than once.

This results in intensified pixels in case of photographic media.

Remedy

Check each pixel to see whether it has already been written to prior to writing a new point.

Example

$r_x = 8$, $r_y = 6$

$2r_y^2x = 0$ (with increment $2r_y^2 = 72$)

$2r_x^2y = 2r_x^2r_y$ (with increment $-2r_x^2 = -128$)

Region 1

$(x_0, y_0) = (0, 6)$

$$p1_0 = r_y^2 - r_x^2 r_y + \tfrac{1}{4} r_x^2 = -332$$

i	p_i	x_{i+1}, y_{i+1}	$2r_y^2 x_{i+1}$	$2r_x^2 y_{i+1}$
0	-332	(1, 6)	72	768
1	-224	(2, 6)	144	768
2	-44	(3, 6)	216	768
3	208	(4, 5)	288	640
4	-108	(5, 5)	360	640
5	288	(6, 4)	432	512
6	244	(7, 3)	504	384

Move out of region 1 since
$2r_y^2x > 2r_x^2y$

Example

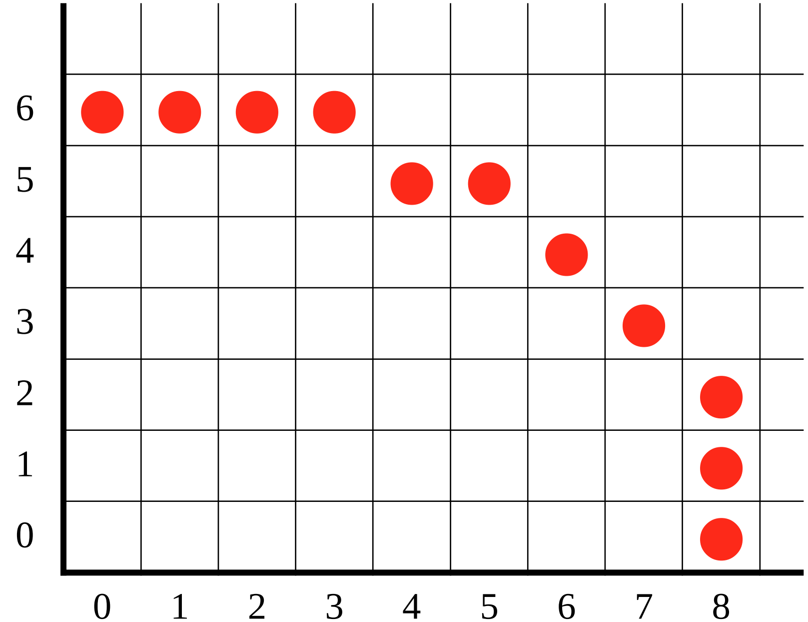
Region 2

(x_0, y_0) = (7, 3) (Last position in region 1)

$$p2_0 = f_{ellipse}(7+\tfrac{1}{2}, 2) = -151$$

i	p_i	x_{i+1}, y_{i+1}	$2r_y^2 x_{i+1}$	$2r_x^2 y_{i+1}$
0	-151	(8, 2)	576	256
1	233	(8, 1)	576	128
2	745	(8, 0)	-	-

Stop at $y = 0$



Exercises

- Draw the ellipse with $r_x = 6$, $r_y = 8$.
- Draw the ellipse with $r_x = 10$, $r_y = 14$.
- Draw the ellipse with $r_x = 14$, $r_y = 10$ and center at (15, 10).