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FUNDAMENTALS OF COMPUTER GRAPHICS (CSIT304)

RASTERIZATION AND 2D TRANSFORMATION

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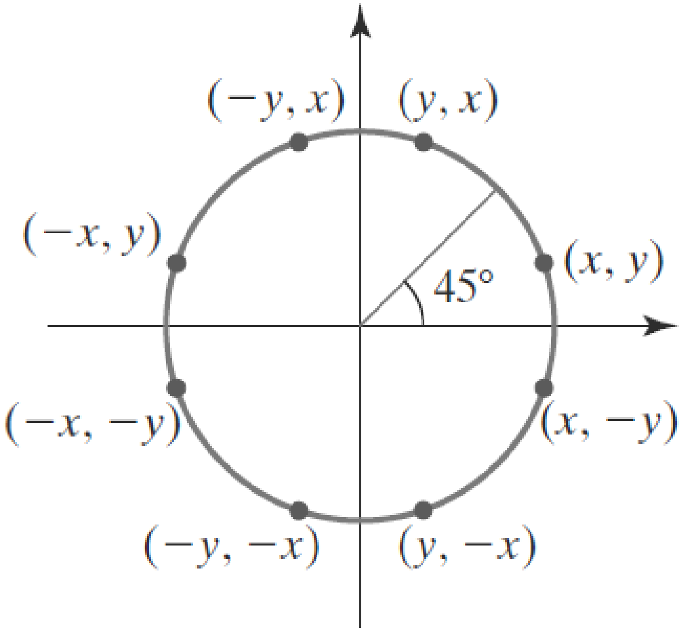
MID-POINT CIRCLE DRAWING ALGORITHM



- **Given a circle (centered at the origin) radius r = 10, write a Python Code that determines position along the circle octant in the first quadrant from x = 0 to x = y as per the midpoint circle algorithm.**

Midpoint Circle Algorithm

1. Input radius r and circle center (x_c, y_c), then set the coordinates for the first point on the circumference of a circle centered on the origin as

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

2. Calculate the initial value of the decision parameter as

$$p_0 = \frac{5}{4} - r$$

3. At each x_k position, starting at $k = 0$, perform the following test: If $p_k < 0$, the next point along the circle centered on $(0, 0)$ is (x_{k+1}, y_k) and

$$p_{k+1} = p_k + 2x_{k+1} + 1$$

   Otherwise, the next point along the circle is $(x_k + 1, y_k - 1)$ and

$$p_{k+1} = p_k + 2x_{k+1} + 1 - 2y_{k+1}$$

   where $2x_{k+1} = 2x_k + 2$ and $2y_{k+1} = 2y_k - 2$.

4. Determine symmetry points in the other seven octants.
5. Move each calculated pixel position (x, y) onto the circular path centered at (x_c, y_c) and plot the coordinate values as follows:

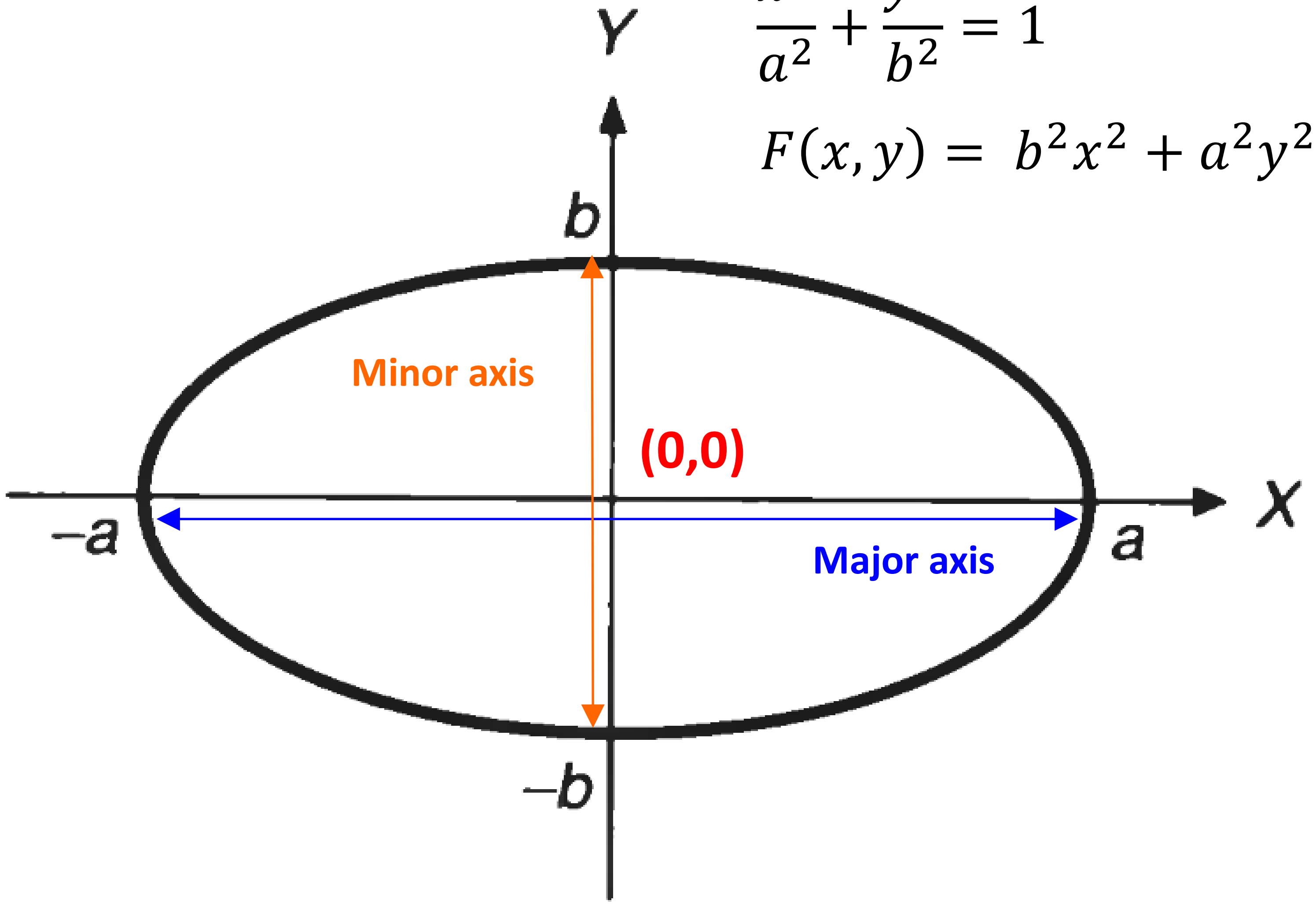
$$x = x + x_c, \qquad y = y + y_c$$

6. Repeat steps 3 through 5 until $x \geq y$.

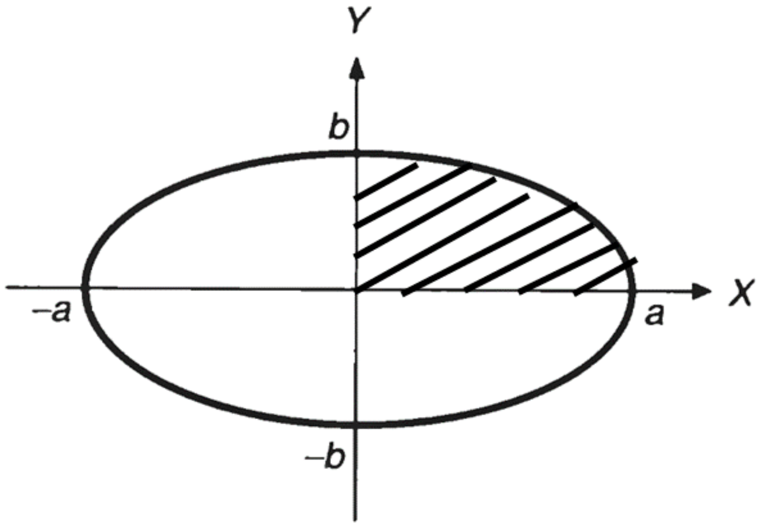
ELLIPSE

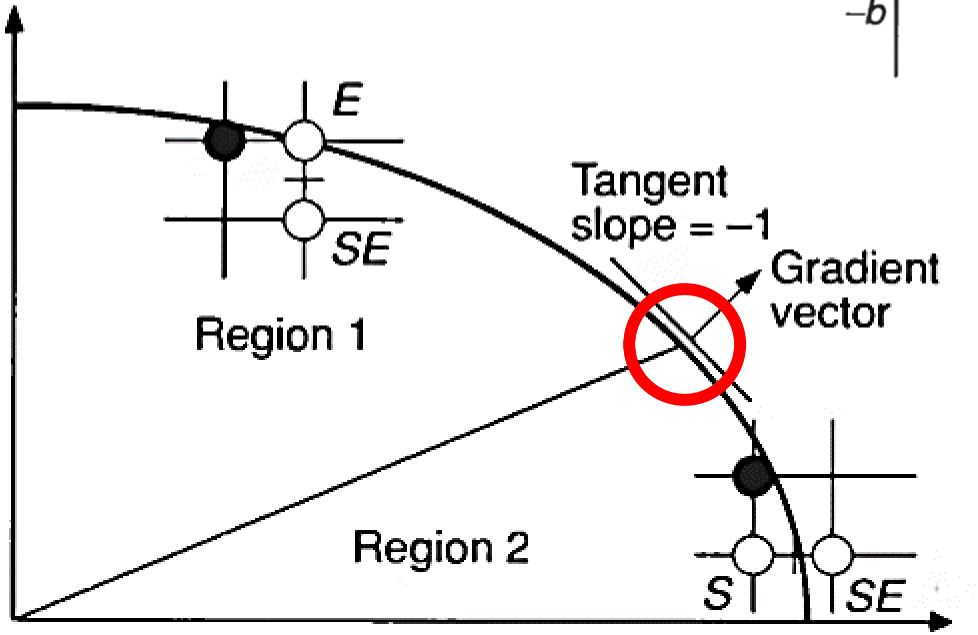
$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

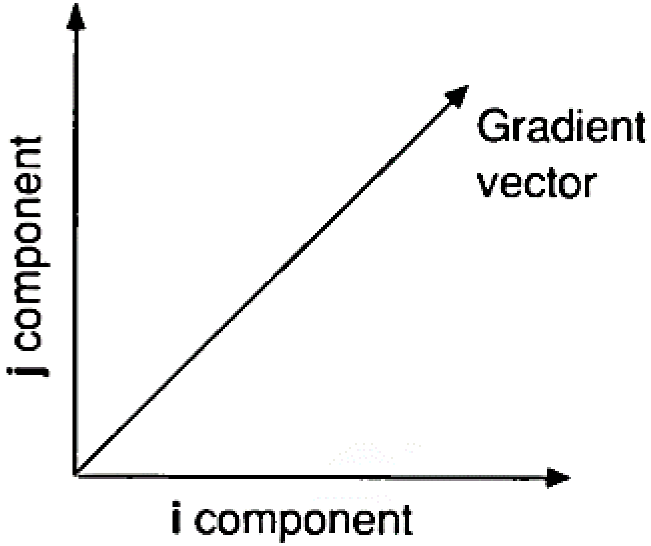
$$F(x, y) = b^2x^2 + a^2y^2 - a^2b^2 = 0$$



FOUR WAY SYMMETRY IN ELLIPSE



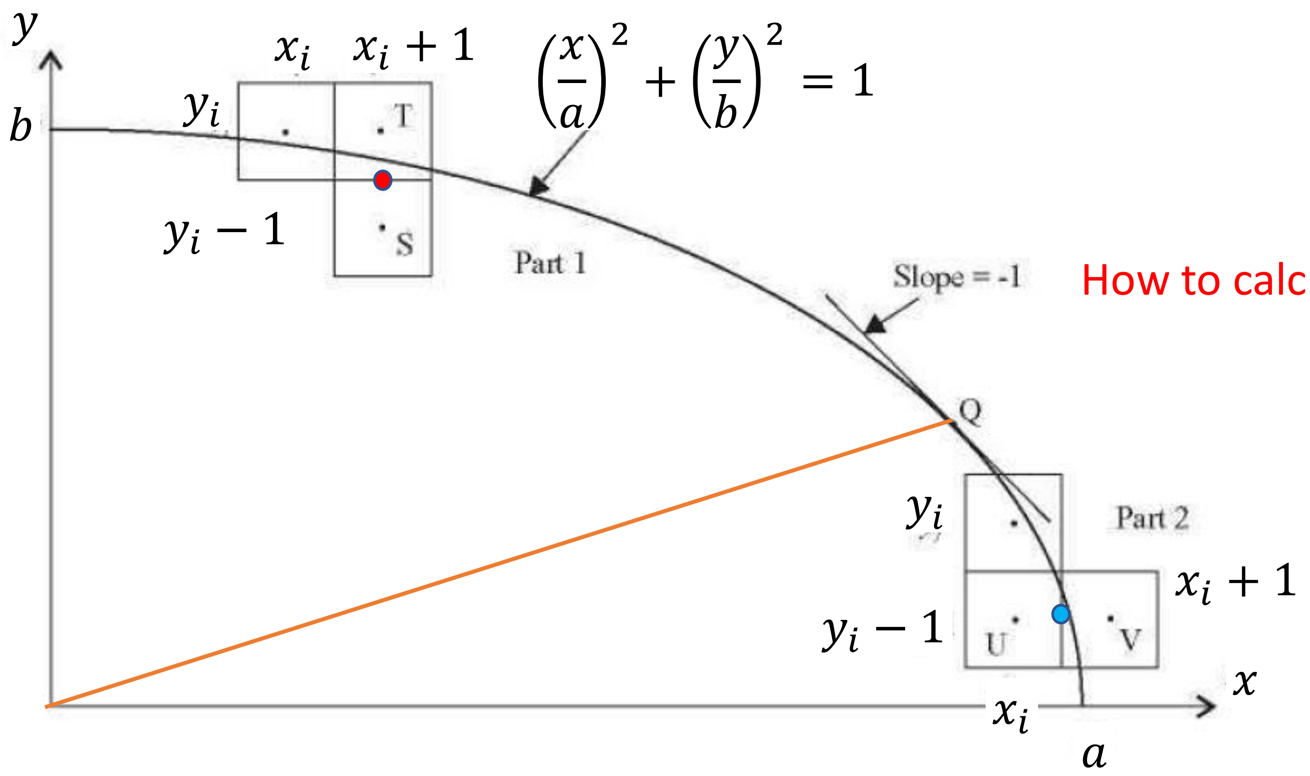




MID-POINT ELLIPSE ALGORITHM

Ellipse Equation $$\left(\frac{(x-x_c)^2}{a^2}\right)+\left(\frac{(y-y_c)^2}{b^2}\right)=1$$

Decision Criteria $$f(x,y)=x^2b^2+y^2a^2-a^2b^2=\begin{cases}<0; Inside\\ =0, On\\ >0; Outside\end{cases}$$



How to calculate Slope?

DERIVATION (PART 1)

$$\boxed{p_i = f(x_i, y_i - 0.5) = (x_i + 1)^2 b^2 + (y_i - 0.5)^2 a^2 - a^2 b^2}$$

Choose T if p<0
Choose S otherwise

$$p_{i+1} = f(x_{i+1}, y_{i+1} - 0.5) = (x_{i+1} + 1)^2 b^2 + (y_{i+1} - 0.5)^2 a^2 - a^2 b^2$$

$$p_{i+1} - p_i = b^2 [(x_{i+1} + 1)^2 - x_{i+1}^2] + a^2 [(y_{i+1} - 0.5)^2 - (y_i - 0.5)^2]$$

$$p_{i+1} = p_i + 2b^2 x_{i+1} + b^2 + a^2 [(y_{i+1} - 0.5)^2 - (y_i - 0.5)^2]$$

If T is chosen $\quad p_{i+1} = p_i + 2b^2 x_{i+1} + b^2$ $\quad$ If S is chosen $\quad p_{i+1} = p_i + 2b^2 x_{i+1} + b^2 - 2a^2 y_{i+1}$

Initial Condition $\quad p_i = f(0, b) = b^2 + (b - 0.5)^2 a^2 - a^2 b^2 = b^2 - a^2 b + a^2/4$

DERIVATION (PART 2)

$$\boxed{q_i = f(x_i, y_i - 0.5) = (x_i + 0.5)^2 b^2 + (y_i - 1)^2 a^2 - a^2 b^2}$$

Choose V if q<0
Choose U otherwise

$$q_{i+1} = f(x_{i+1} + 0.5, y_{i+1} - 1) = (x_{i+1} + 0.5)^2 b^2 + (y_{i+1} - 1)^2 a^2 - a^2 b^2$$

$$q_{i+1} - q_i = b^2[(x_{i+1} + 0.5)^2 - (x_i + 0.5)^2] + a^2[(y_{i+1} - 1)^2 - (y_{i+1})^2]$$

$$q_{i+1} = q_i + b^2[(x_{i+1} + 0.5)^2 - (x_i + 0.5)^2] - 2a^2 y_{i+1} + a^2$$

If V is chosen $\quad q_{i+1} = q_i + 2b^2 x_{i+1} - 2a^2 y_{i+1} + a^2$

If U is chosen $\quad q_{i+1} = q_i - 2a^2 y_{i+1} + a^2$

Initial Condition $\quad q_i = f(x_k + 0.5, y_k - 1)$

ELLIPSE GENERATION ALGORITHM

Midpoint Ellipse Algorithm

1. Input r_x, r_y, and ellipse center (x_c, y_c), and obtain the first point on an ellipse centered on the origin as
$$(x_0, y_0) = (0, r_y)$$
2. Calculate the initial value of the decision parameter in region 1 as
$$p1_0 = r_y^2 - r_x^2 r_y + \frac{1}{4} r_x^2$$
3. At each x_k position in region 1, starting at $k = 0$, perform the following test: If $p1_k < 0$, the next point along the ellipse centered on (0, 0) is (x_{k+1}, y_k) and
$$p1_{k+1} = p1_k + 2r_y^2 x_{k+1} + r_y^2$$
Otherwise, the next point along the ellipse is $(x_k + 1, y_k - 1)$ and
$$p1_{k+1} = p1_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_y^2$$
with
$$2r_y^2 x_{k+1} = 2r_y^2 x_k + 2r_y^2, \qquad 2r_x^2 y_{k+1} = 2r_x^2 y_k - 2r_x^2$$
and continue until $2r_y^2 x \geq 2r_x^2 y$.
4. Calculate the initial value of the decision parameter in region 2 as
$$p2_0 = r_y^2 \left(x_0 + \frac{1}{2}\right)^2 + r_x^2 (y_0 - 1)^2 - r_x^2 r_y^2$$
where (x_0, y_0) is the last position calculated in region 1.
5. At each y_k position in region 2, starting at $k = 0$, perform the following test: If $p2_k > 0$, the next point along the ellipse centered on (0, 0) is $(x_k, y_k - 1)$ and
$$p2_{k+1} = p2_k - 2r_x^2 y_{k+1} + r_x^2$$
Otherwise, the next point along the ellipse is $(x_k + 1, y_k - 1)$ and
$$p2_{k+1} = p2_k + 2r_y^2 x_{k+1} - 2r_x^2 y_{k+1} + r_x^2$$
using the same incremental calculations for x and y as in region 1. Continue until $y = 0$.
6. For both regions, determine symmetry points in the other three quadrants.
7. Move each calculated pixel position (x, y) onto the elliptical path centered on (x_c, y_c) and plot these coordinate values:
$$x = x + x_c, \qquad y = y + y_c$$

PYTHON CODE

- **Write a Python Code that scan converts an ellipse, given the values of major, minor axis and the center (Given input ellipse parameters rx =8 and ry =6, Origin = (0,0)).**

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THANK YOU