Name: **SID:** **LAB Section:**

Lab 5 - Part 1: Bresenham's line algorithm / midpoint algorithm

References: https://en.wikipedia.org/wiki/Bresenham%27s_line_algorithm

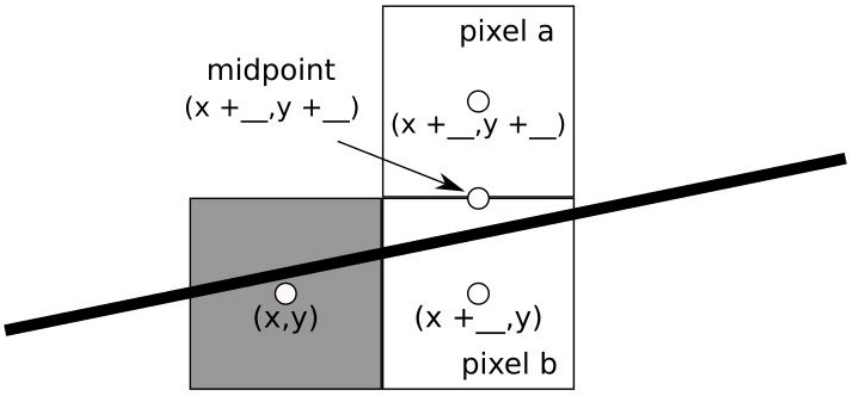
This Lab consists of implementing the midpoint algorithm to draw continuous lines using only integer operations. Recall the line equation is:

(1) **y = mx + b,** where m is the slope and b is the y intercept.

Given two points p0 = (x0, y0) and p1 = (x1, y1), the slope is calculated as:

(2) **m = (y1 - y0) / (x1 - x0) = dy / dx**

Consider 0 <= m <= 1 (line in angle between 0 and 45 degrees), the idea is to determine whether which of the following two pixels we should draw. Complete the missing coordinates of the points below.



In particular, we can evaluate the midpoint between a and b using a function f(x,y) that returns a **positive number if the line is above** the midpoint and **negative if the line is below** the midpoint.

The function f(x,y) should be zero if the midpoint lies on the line:

(3) f(x, y) = 0 = **mx + b - y**

Rewrite the right-hand-side (RHS) of Equation (3) in the form **Ax + By + C,** where A, B, and C depends on dx, dy and b only.

(4) f(x, y) =

where A = _____, B = _____, C = _____
We want to make a decision on whether to draw pixel a or b using f(x, y) on a sequence of points from p0 to p1. Define variables da and db to hold the difference of f(x, y) from a and b to the previous midpoint (x + 1, y + 1/2). Use Equation (4) to rewrite Equations (5) and (6) as function of A and B (you won´t need C).

(5) da = f(x + 2, y + 3/2) - f(x + 1, y + 1/2) =

(6) db = f(x + 2, y + 1/2) - f(x + 1, y + 1/2) =

Final detail, we need to calculate the difference between the second and first point in order to use Equations (5) and (6) in a loop.

(7) dinit = f(x0 + 1, y0 + 1/2) - f(x0, y0) =

We only care whether d is positive or negative. Hence, we can multiply dinit, da and db by 2 to remove 1/2 resulting in equations containing only integers.

Using Equations (4) to (7), complete the code Bresenham's algorithm below:

```
Bresenham(x0, y0, x1, y1):

  dx = x1 - x0
  dy = y1 - y0

  D = ________ // initialize D using dinit

  y = y0

  for x = x0 to x1:

    set_pixel(x, y)

    if D > 0:
       y = y + 1

       D = _________ // D is positive, use da

    D = _________ // D is negative, use db
```

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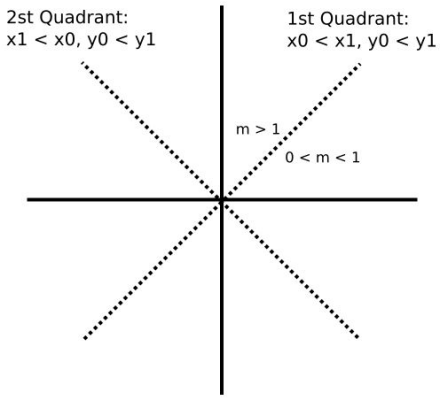
Lab 5 - Part 2: Implementing the midpoint algorithm

We considered 0 <= m <= 1 (line in angle between 0 and 45 degrees) to write the code in the previous part. How can we manage other line angles? Feel free to think a little bit about it and to look at the Wikipedia page (link on Part 1). Here is a free blank space and a diagram :)



Download the skeleton code on iLearn and write the midpoint algorithm in the function **draw_line_MPA** in the file **application.cpp**.

To draw a pixel, you can use **set_pixel(x, y, linecolor)**, where linecolor is given to you as argument of the draw_line_MPA function.

The following commands are available:

- Click and hold to draw lines.
- Type ¨c¨ to clear old lines.
- Type ¨a¨ to generate 1K random lines.
- Type ¨A¨ to generate 1M random lines.
- Type ¨m¨ to toggle between the MPA and the DDA algorithms.
- Type ¨]¨ ¨[¨ to change point-size.

Make sure your code runs faster than the DDA algorithm. Why the DDA algorithm is slower (feel free to take a look at the draw_line_DDA function)?

Run your MPA algorithm 3 times with 1K and 1M lines without increasing the point-size. Run the DDA algorithm 3 times with 1K and 1M lines without increasing the point-size. Fill the table below with the running time.

	Run 1	**Run 2**	**Run 3**
DDA (1K / 1M)	/	/	/

MPA (1K / 1M)	/	/	/