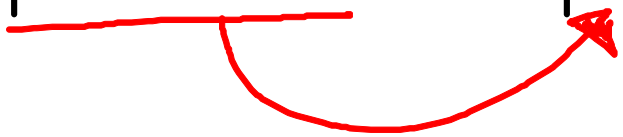
# Rasterization and Aliasing

Lecture 27

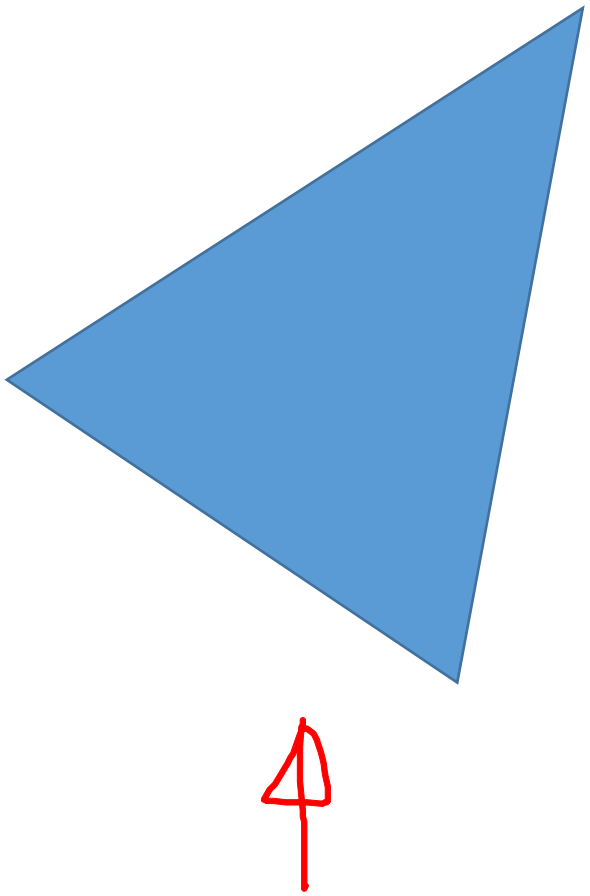
# Rasterization

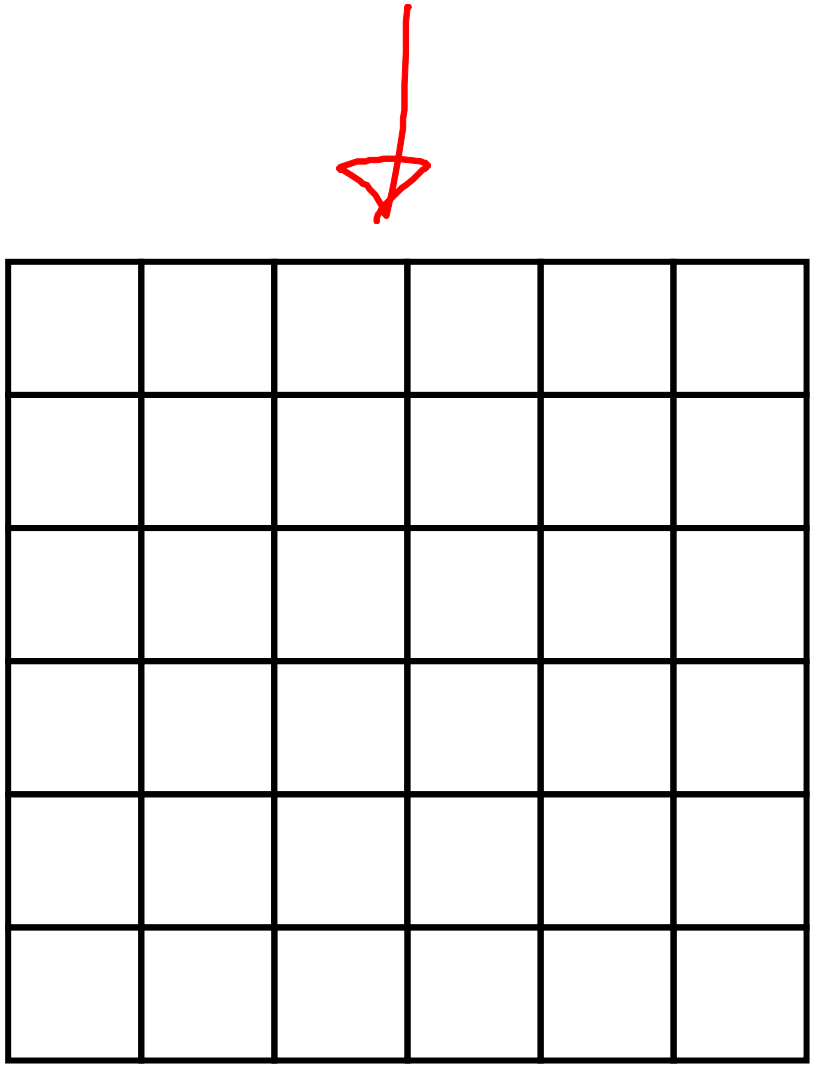
Figure out which pixels a primitive “covers”

Turns primitives into pixels



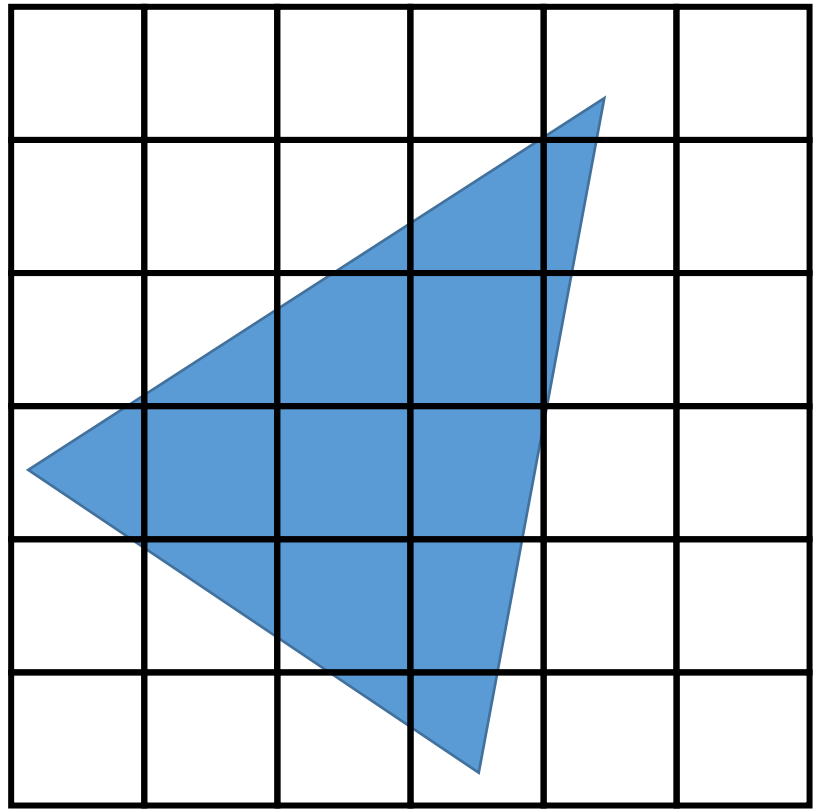
# Rasterization





# Rasterization

Convert primitives to pixels



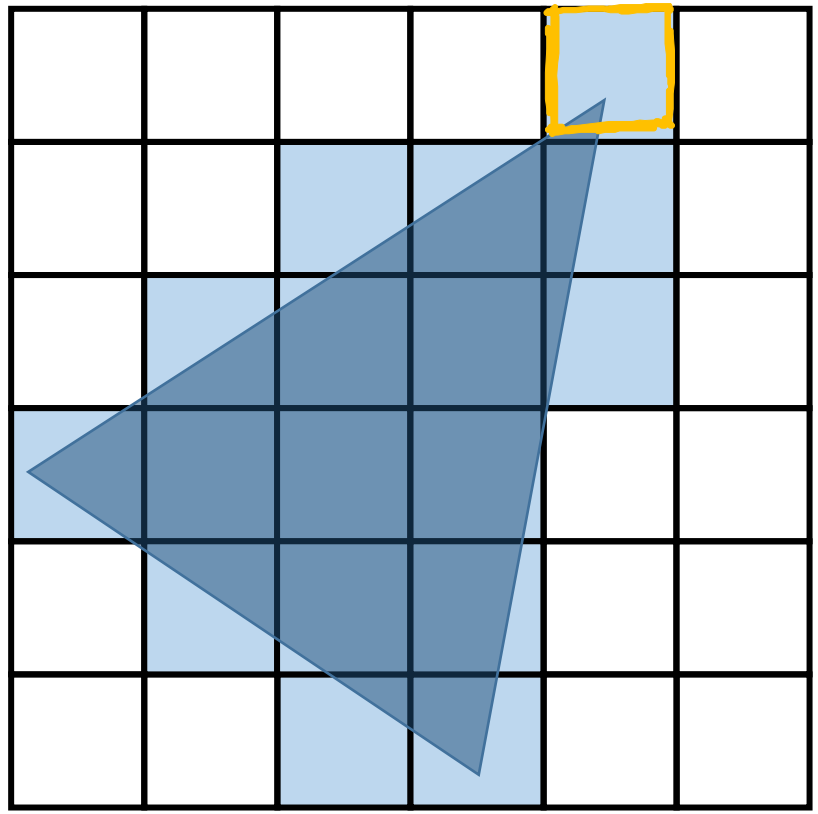
# Rasterization

Convert primitives to pixels

For now consider coverage

Yes/No decision

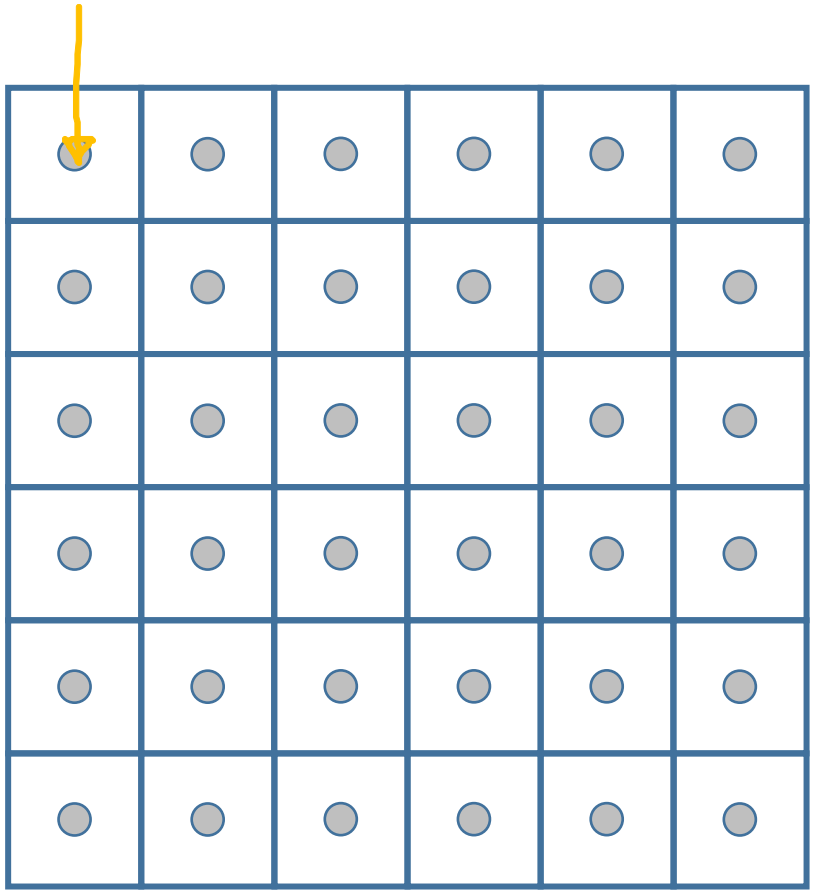
Partial fill later



# A pixel is a little square?

Think of pixels as points

The center of the square



Repeat after me…

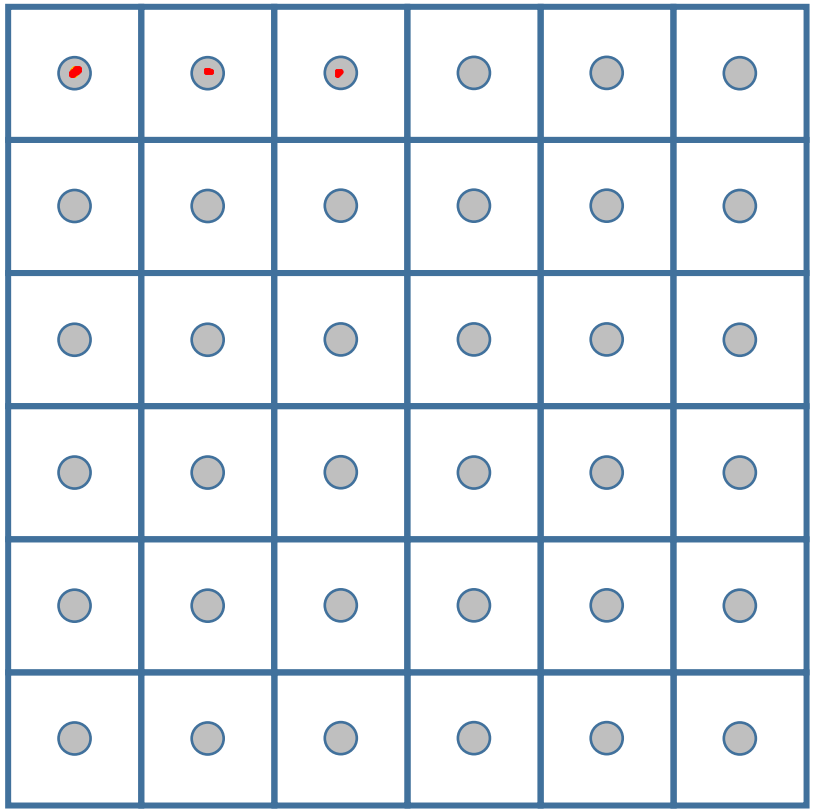
# A pixel is not a little square

# Pixels are Point Samples

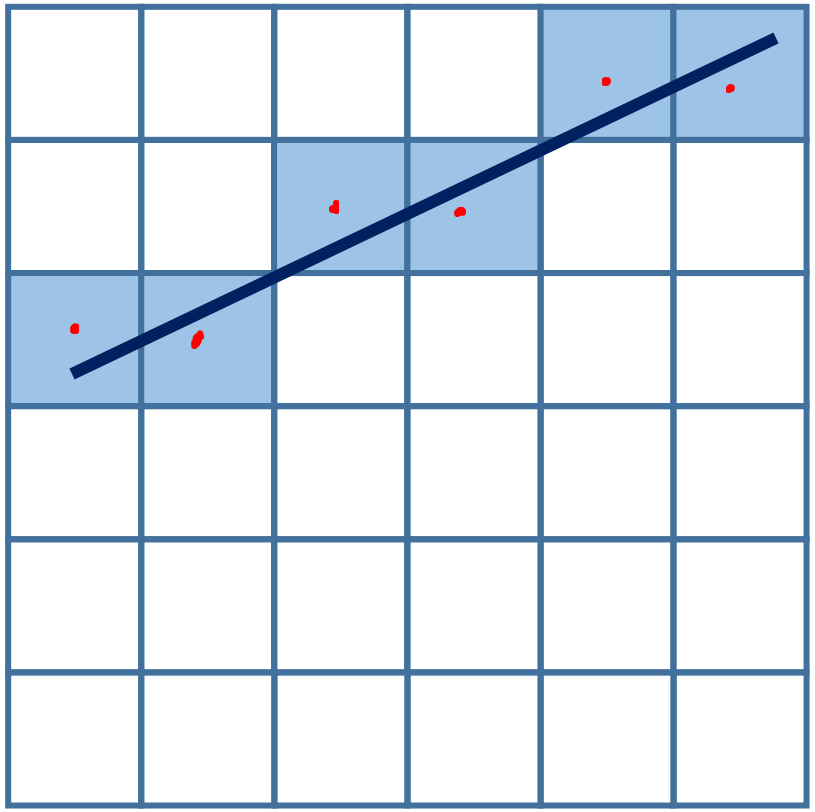
Specific positions

The center of the square (convention)

Makes everything more consistent



# Lines



# Drawing Lines

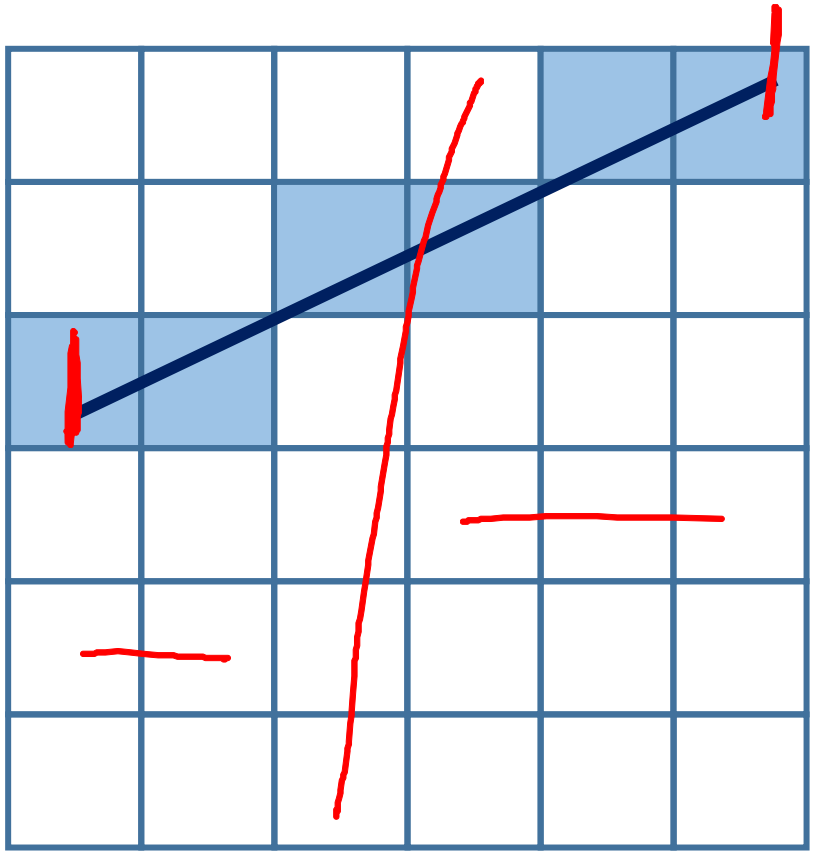
No gaps

1 pixel per column

(for slopes -1 to 1)

1 pixel per row

(for other slopes)



# Brezenham / Midpoint Algorithm

Each octant is special

(this is for 1st octant)

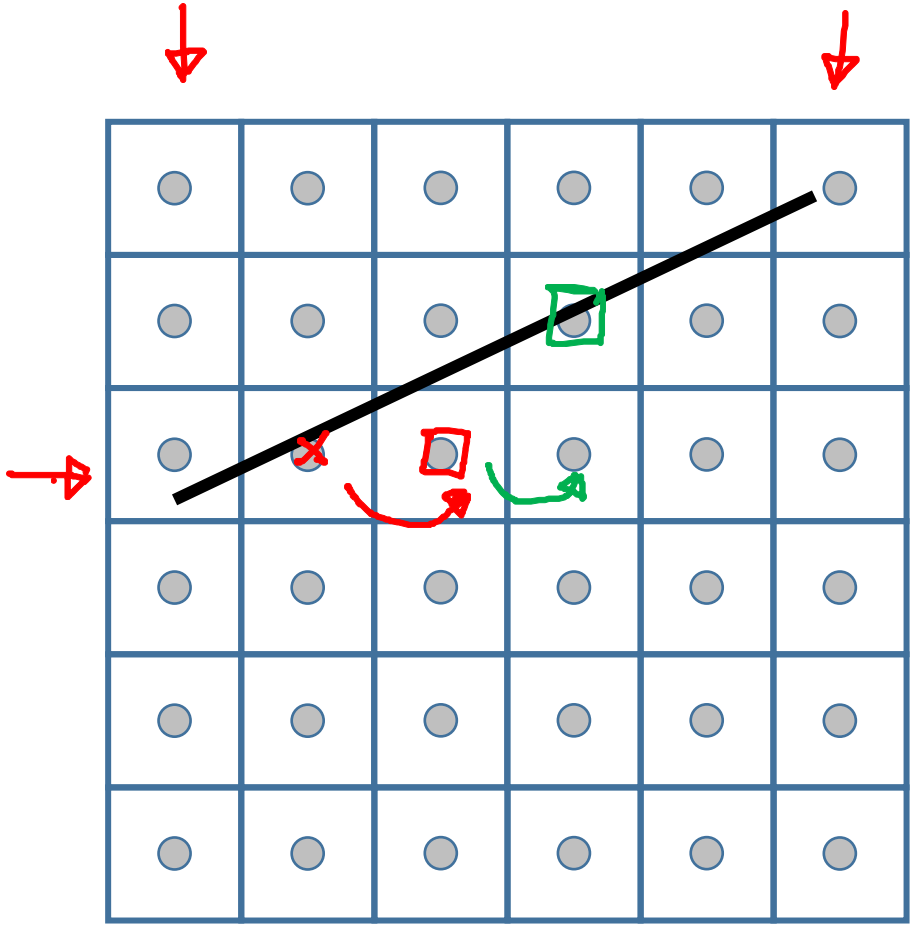
For each column:

pick closest point

As you move ~~right~~ to ~~left…~~ left to right

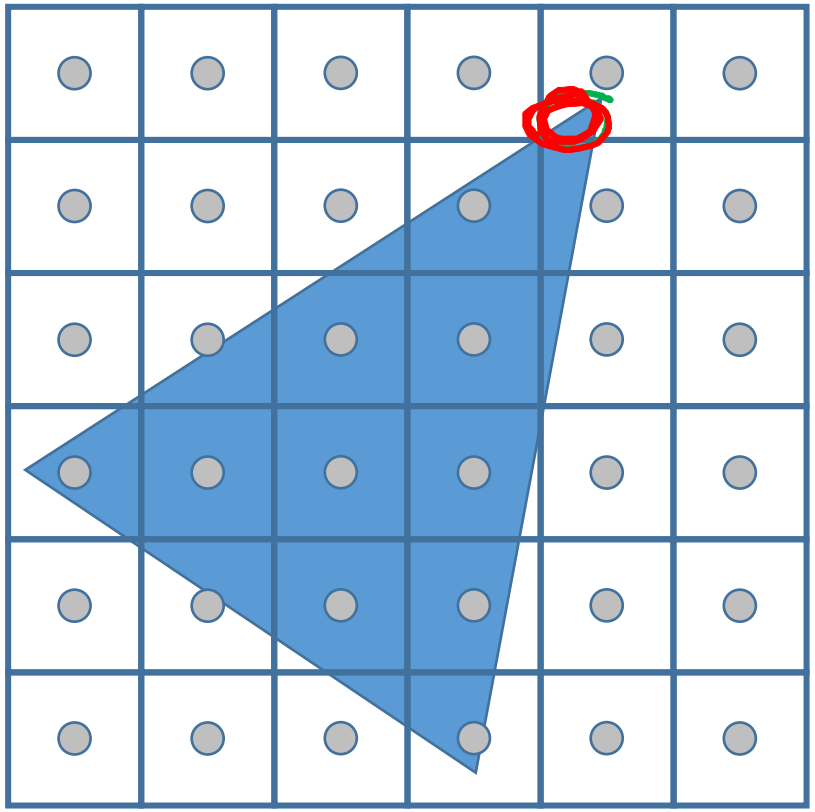
stay the same

move up



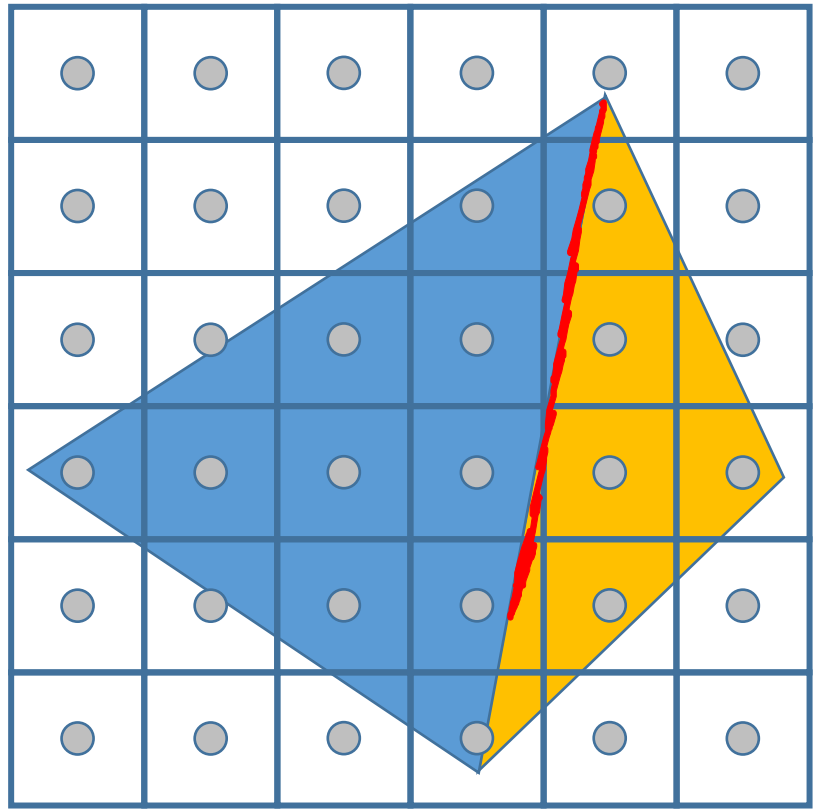
# Triangles

Does the triangle cover the sample point?



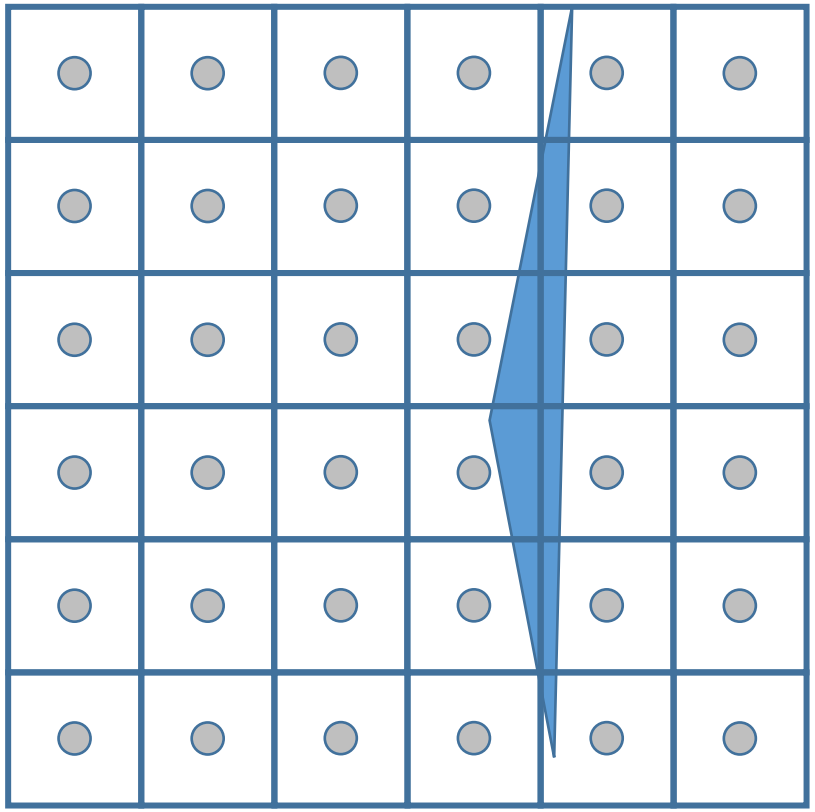
# Point Coverage

Handles edges consistently



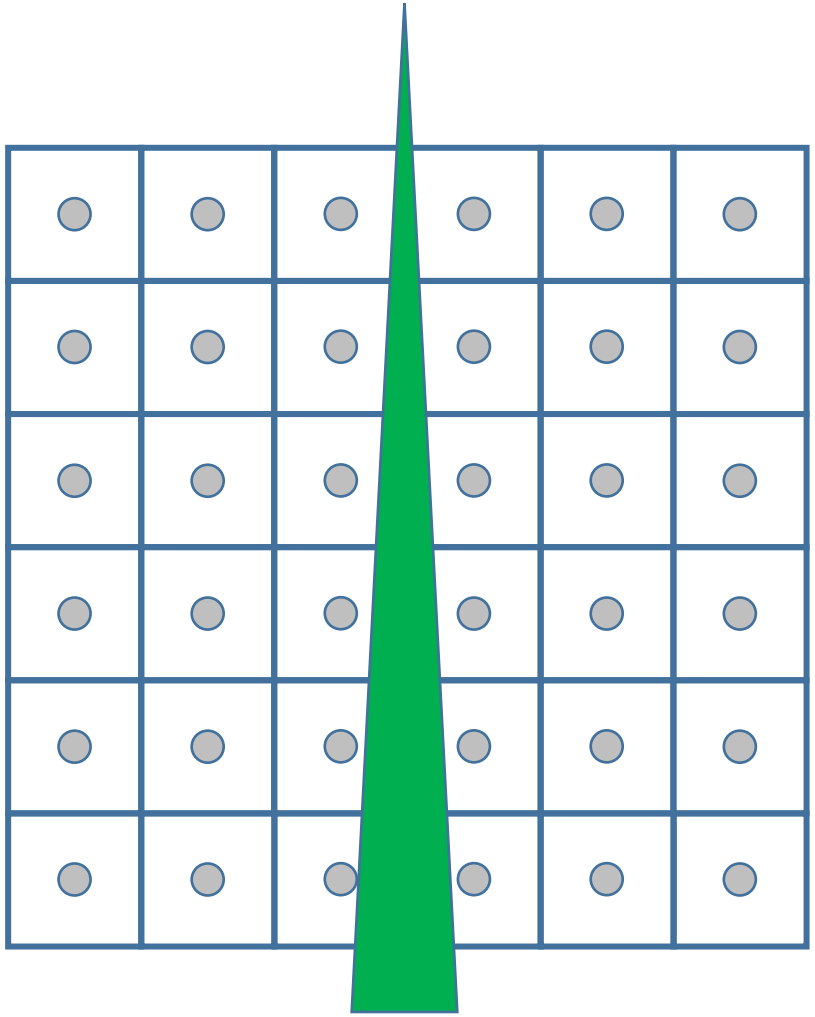
# Triangles

A triangle could get lost between pixels



# Triangles

A triangle could get lost between pixels



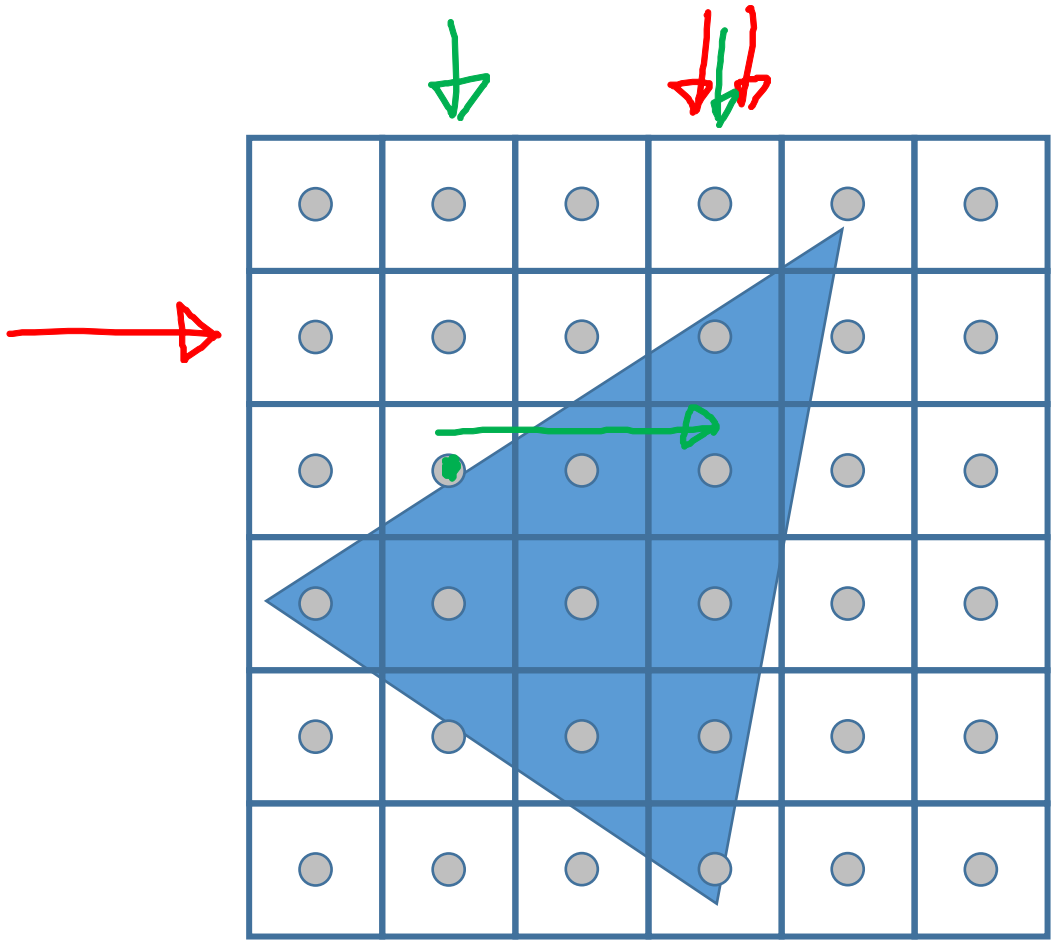
# Scanline Algorithm

For each row

find left and right

fill

Use line drawing to get edges



# Hardware triangle drawing

# Barycentric Coordinates

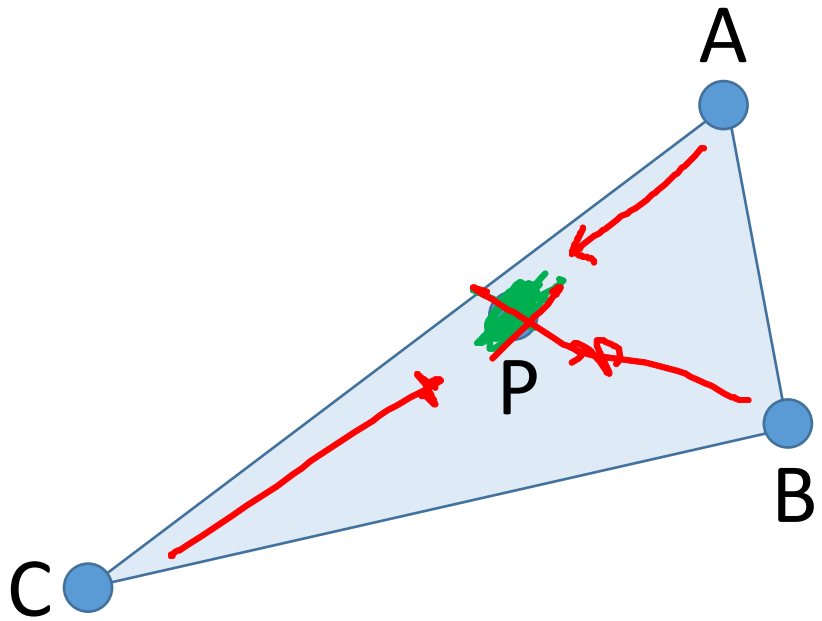
Any point in the plane is a convex combination of the vertices of the triangle

$P=\alpha A+\beta B+\gamma C$

$\alpha+\beta+\gamma=1$

Inside triangle

$0 <= \alpha, \beta, \gamma <= 1$



# Barycentric Coords are Useful!

Every point in plane has a coordinate

$(\alpha\ \beta\ \gamma)$ such that: $\alpha + \beta + \gamma = 1$

Easy test inside the triangle

$0 <= \alpha, \beta, \gamma <= 1$

Interpolate values across triangles

$$x_p = \alpha\, x_1 + \beta\, x_2 + \gamma\, x_3$$

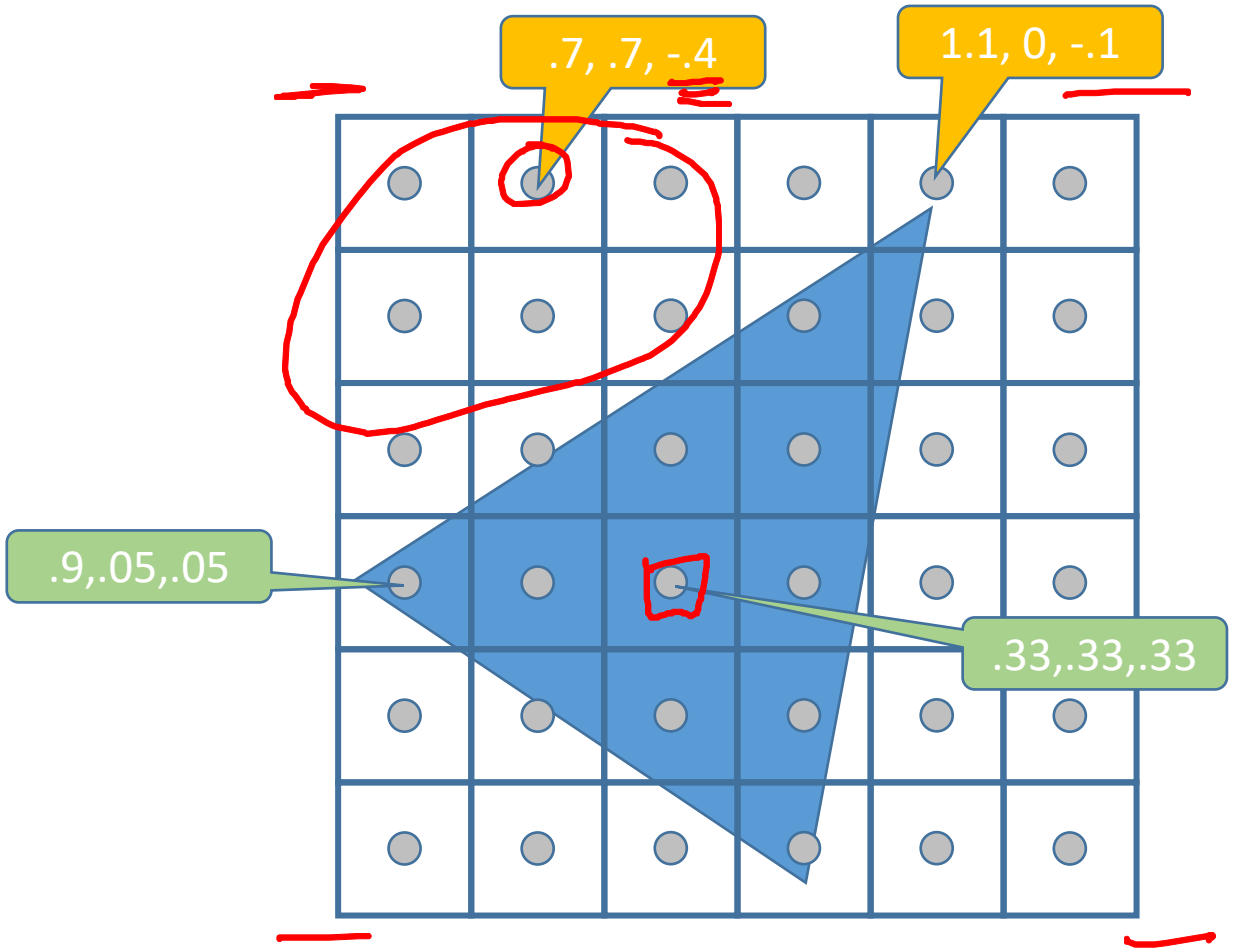
$$c_p = \alpha\, c_1 + \beta\, c_2 + \gamma\, c_3$$

# Hardware Rasterization

For each point:

Compute barycentric coords

Decide if in or out



# Wasteful?

Can do all points in parallel

We want the coordinates (for interpolation)

Does the right things for touching triangles

Each point in 1 triangle

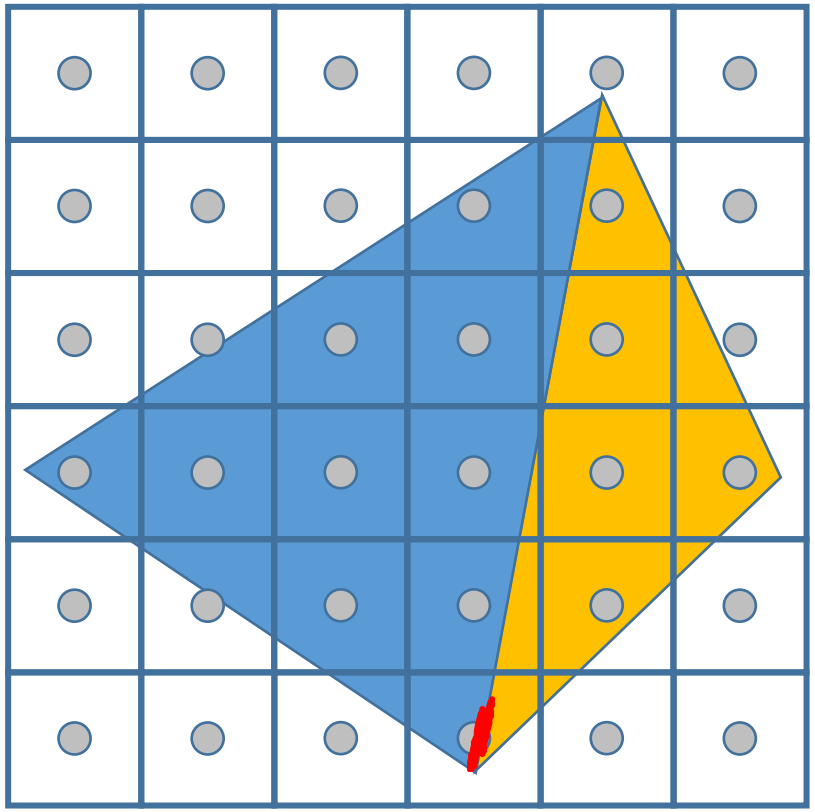
# Hardware Rasterization

Each center point in one triangle

If we choose consistently for “on-the-edge” cases

Over simplified version:

0 <= a,b,c < 1



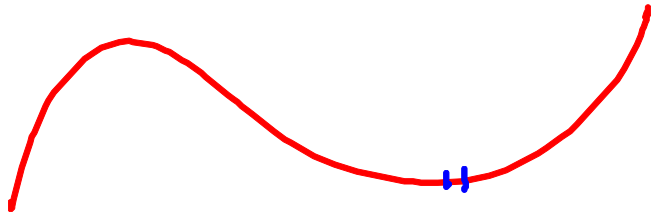
# Aliasing and Anti-Aliasing

Living with the problems of finite representations

# Aliasing: The problem

Continuous World

Infinite information!



Discrete Computer

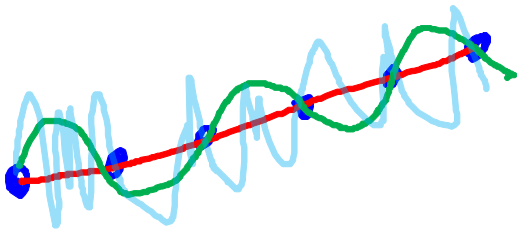
Finite representation

# Aliasing

Any representation may have multiple interpretations

We don't know which one is right

They are aliases of each other



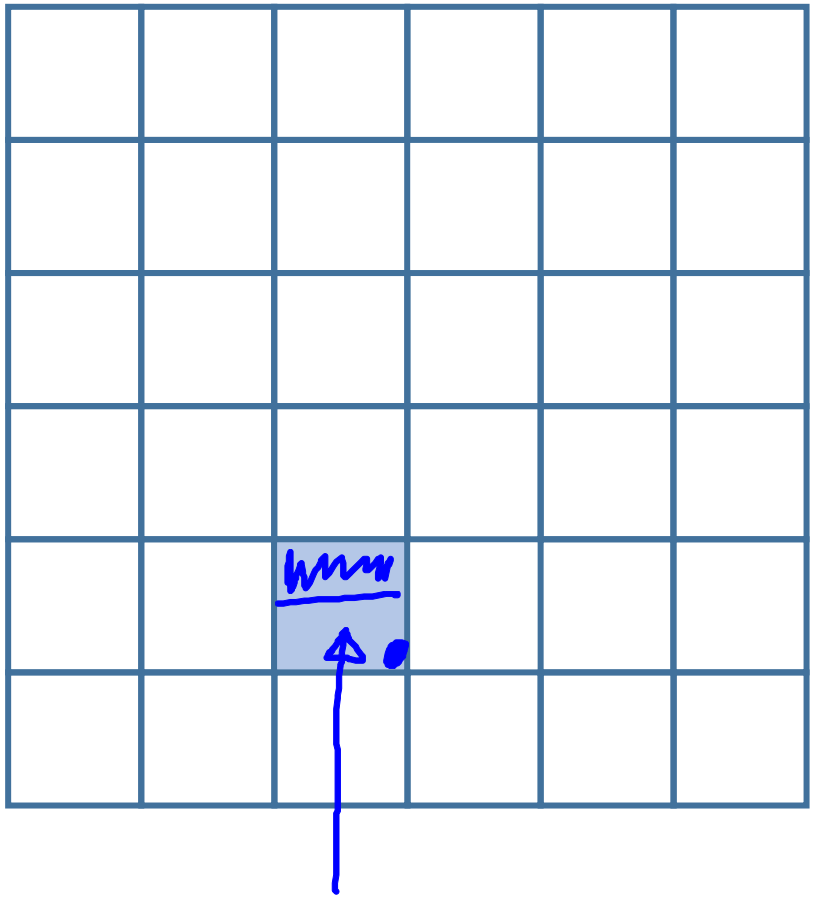
different in world

⇏

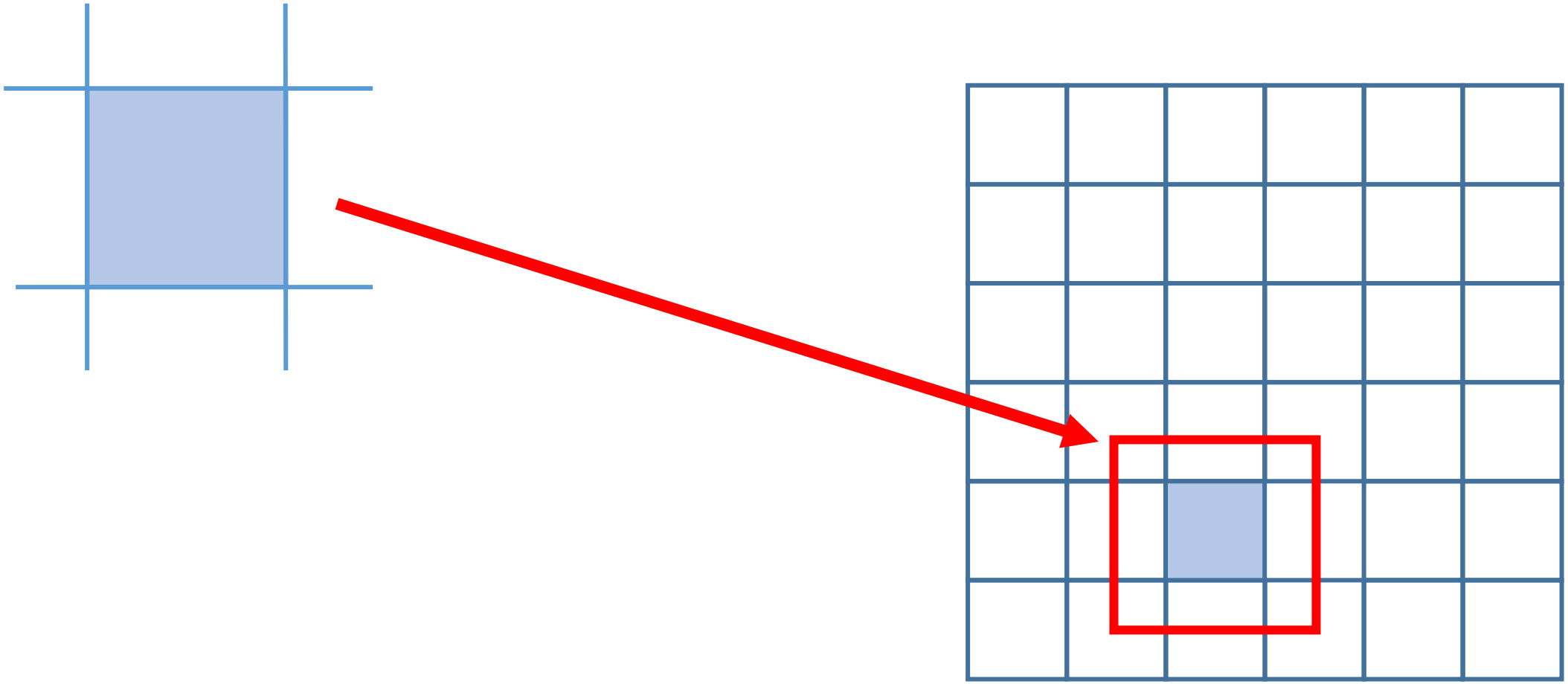
Same in discrete

# Aliasing
# It also happens in the “little square model”

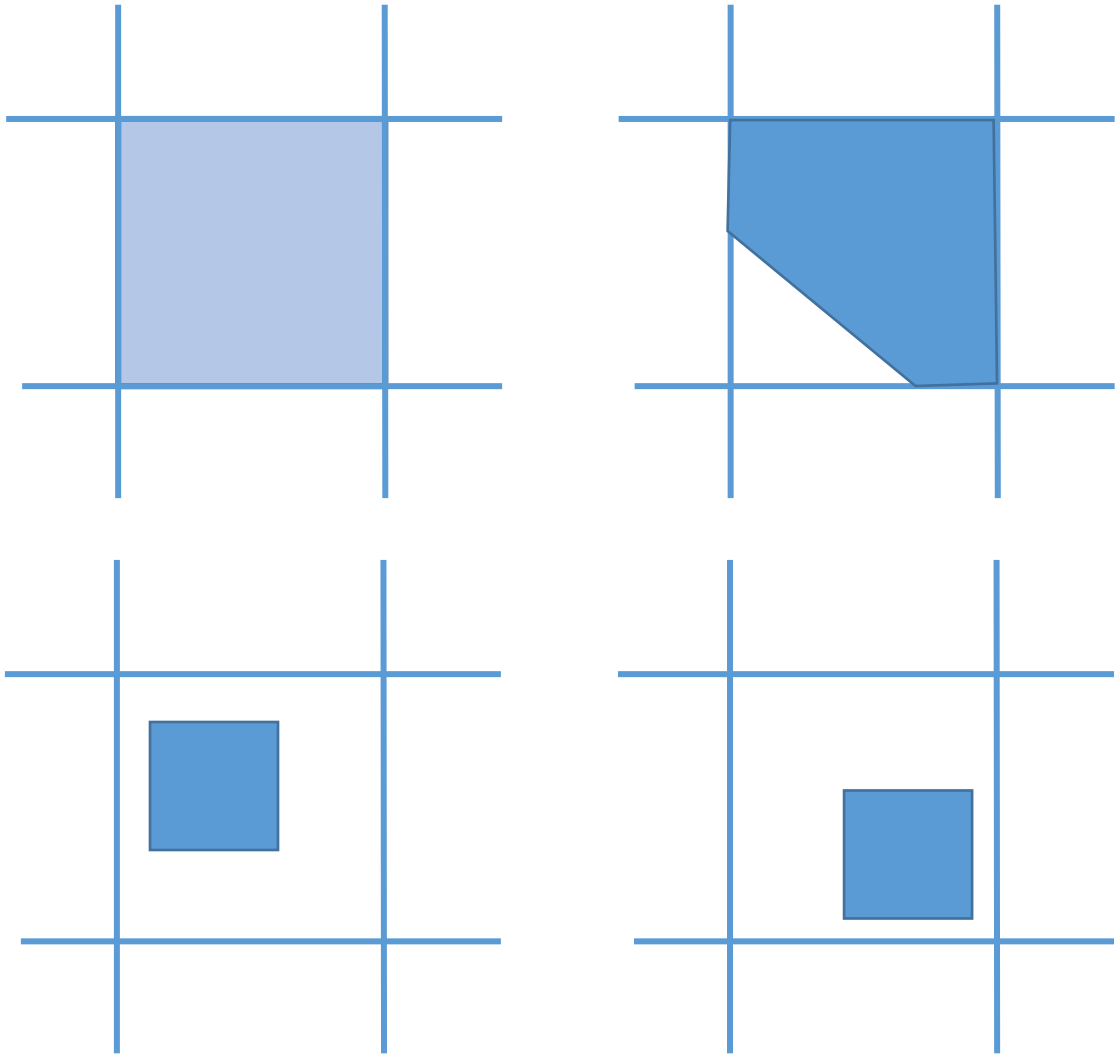
A pixel has 1 color

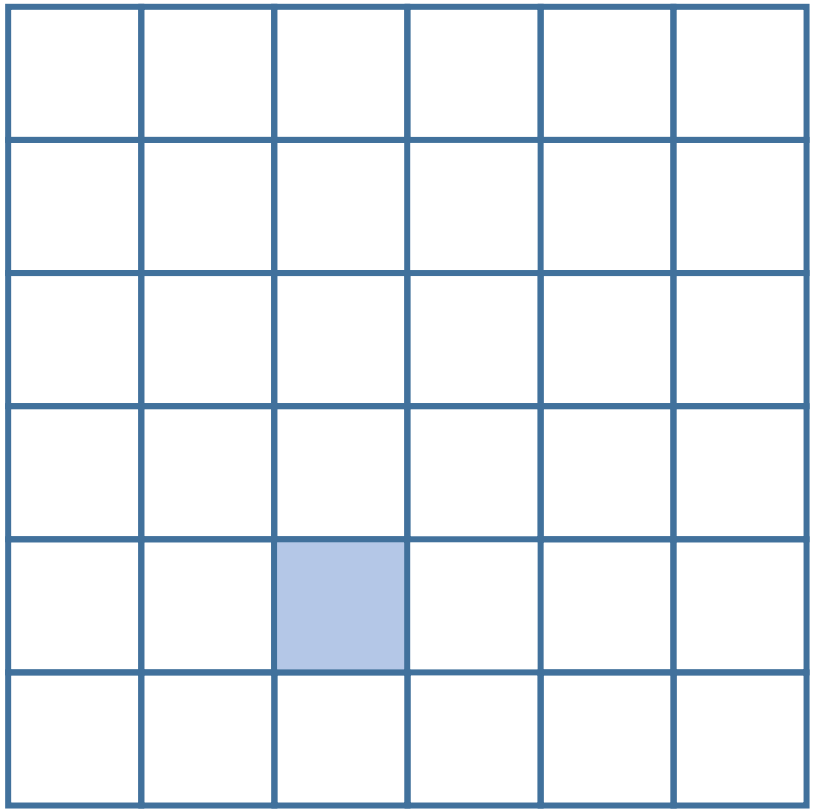


# Which one is it?



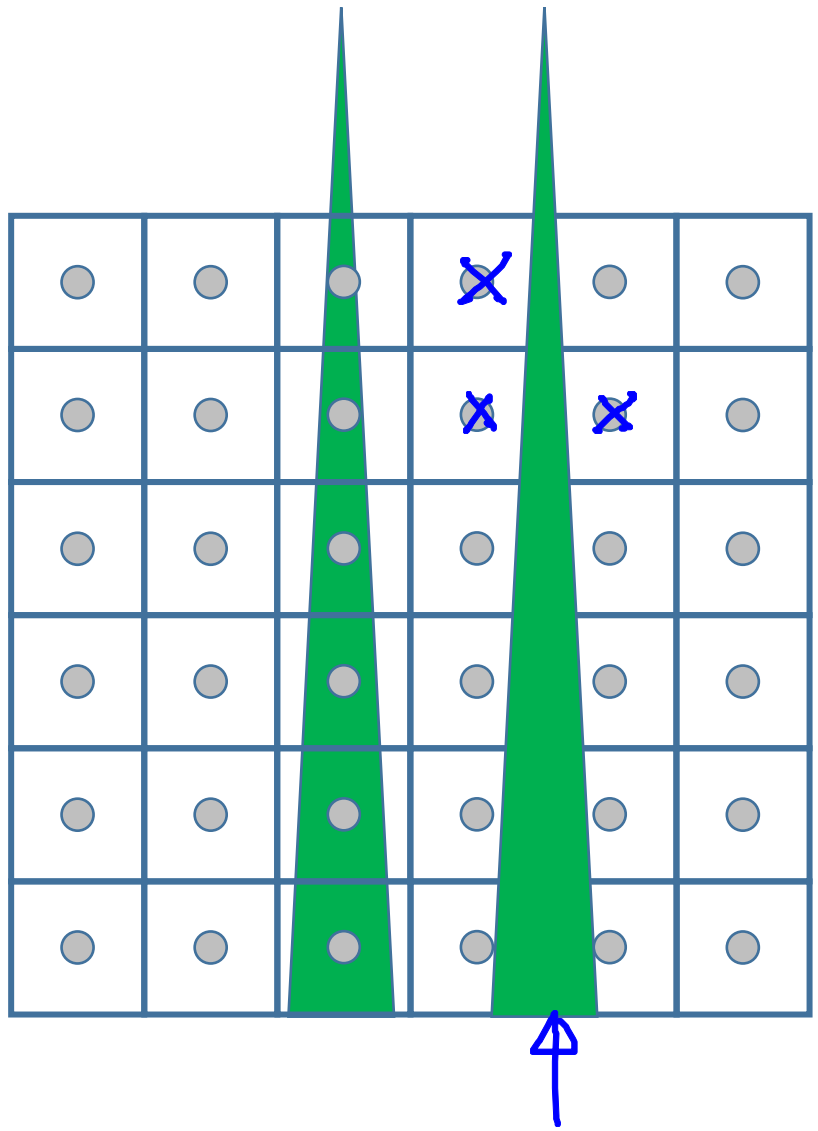
# Which one is it?





# No Squares

Same thing – we only know what happens at the sample!



# Many possible original signals
# Same discrete representation

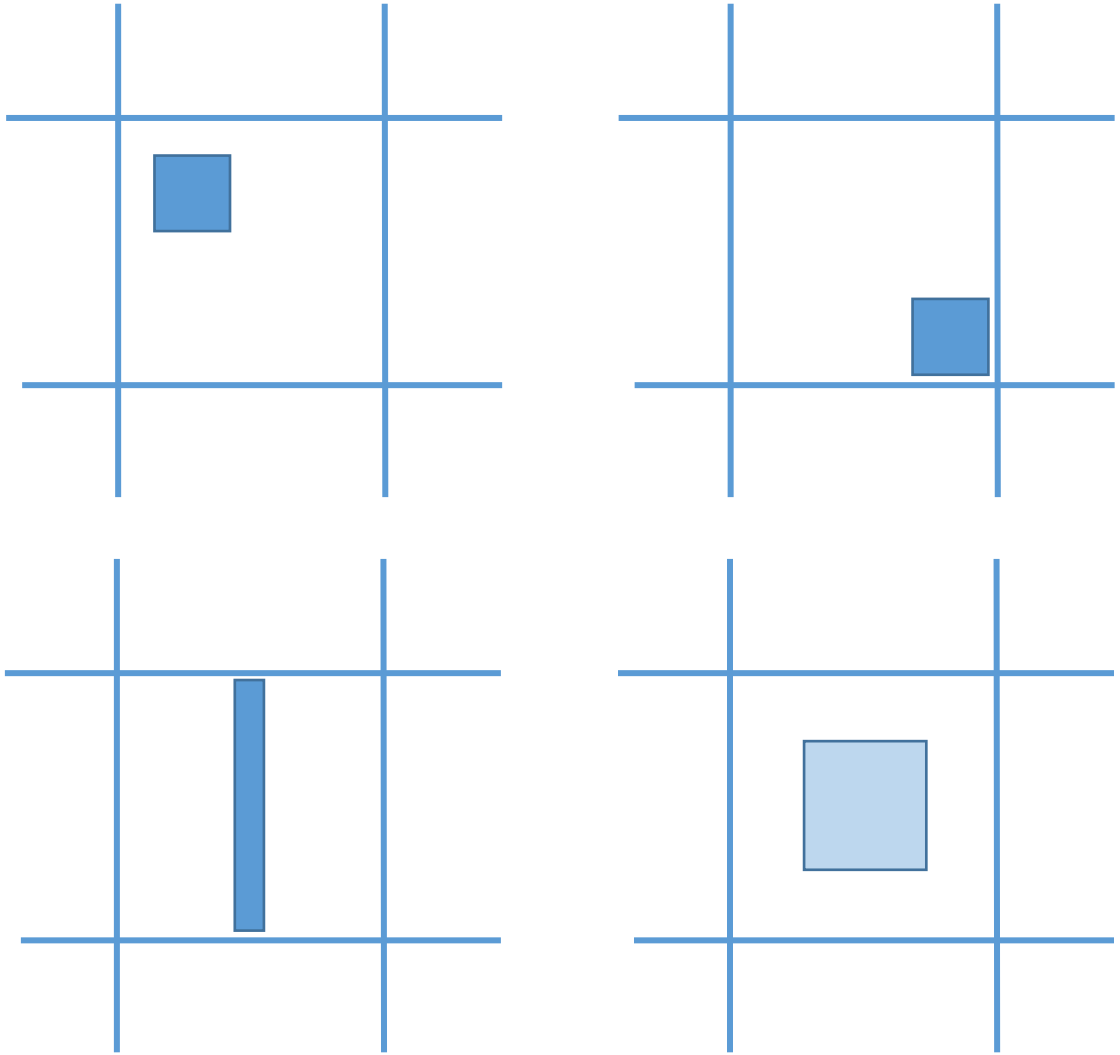
# Aliasing

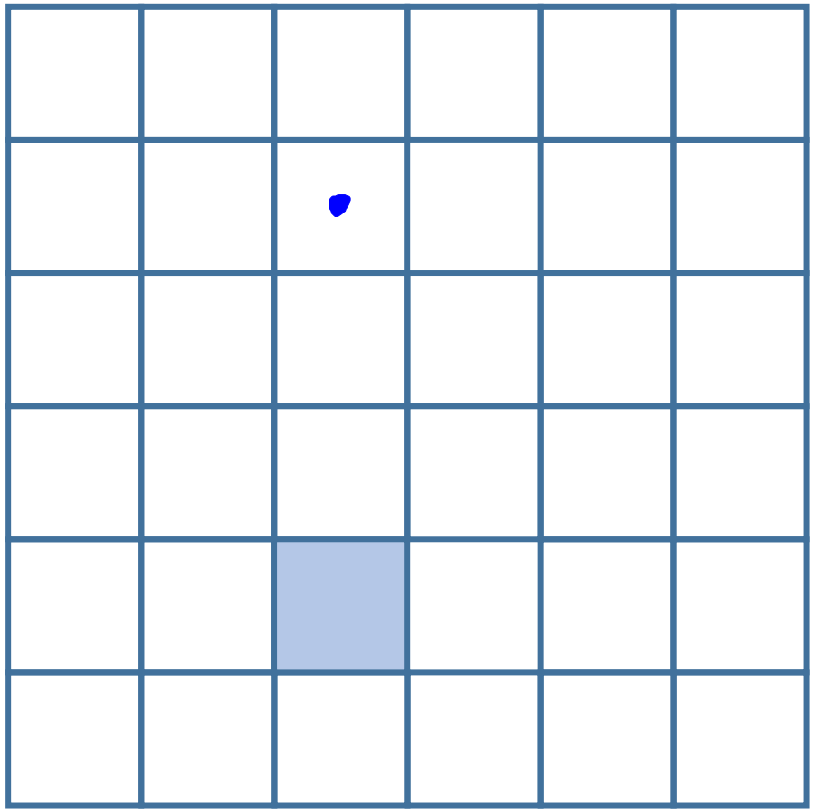
Many possible “signals”

Same discrete representation

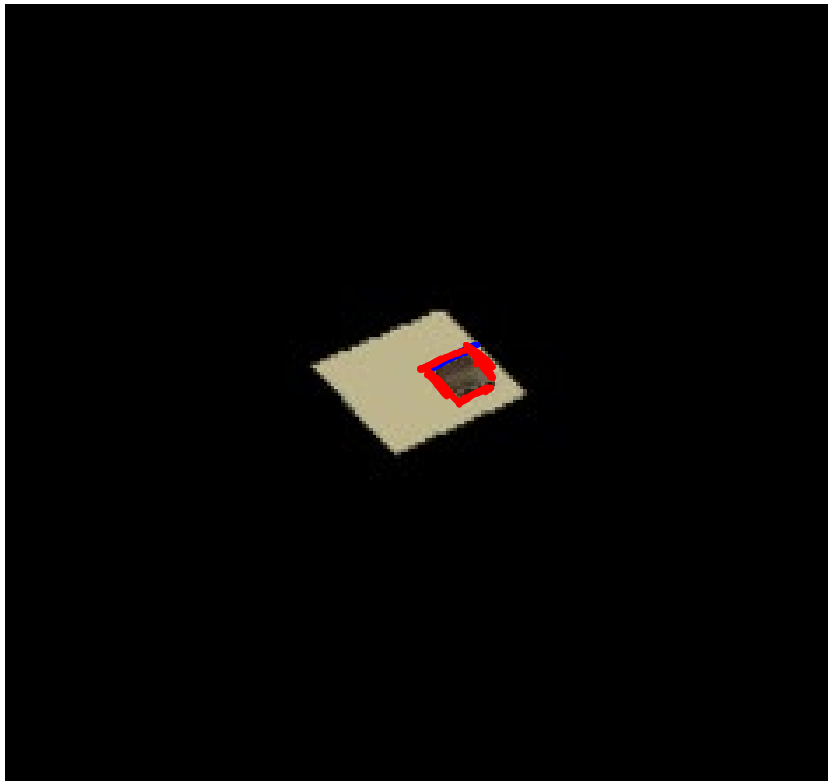
# This problem comes up everywhere...

# Point positions





# Texture Sampling

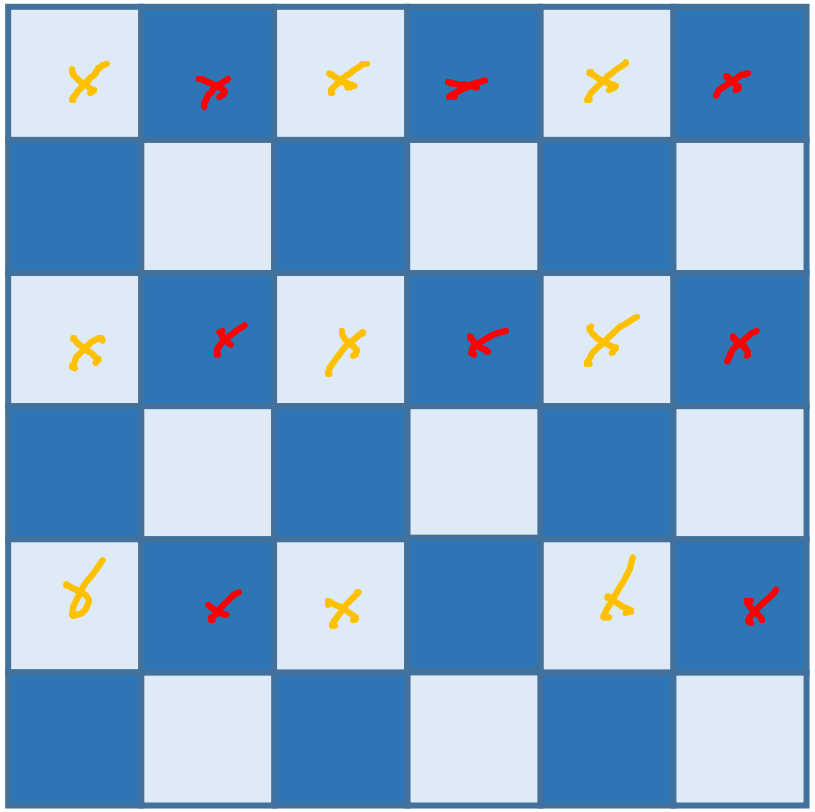


# Make an image (e.g. texture) smaller…

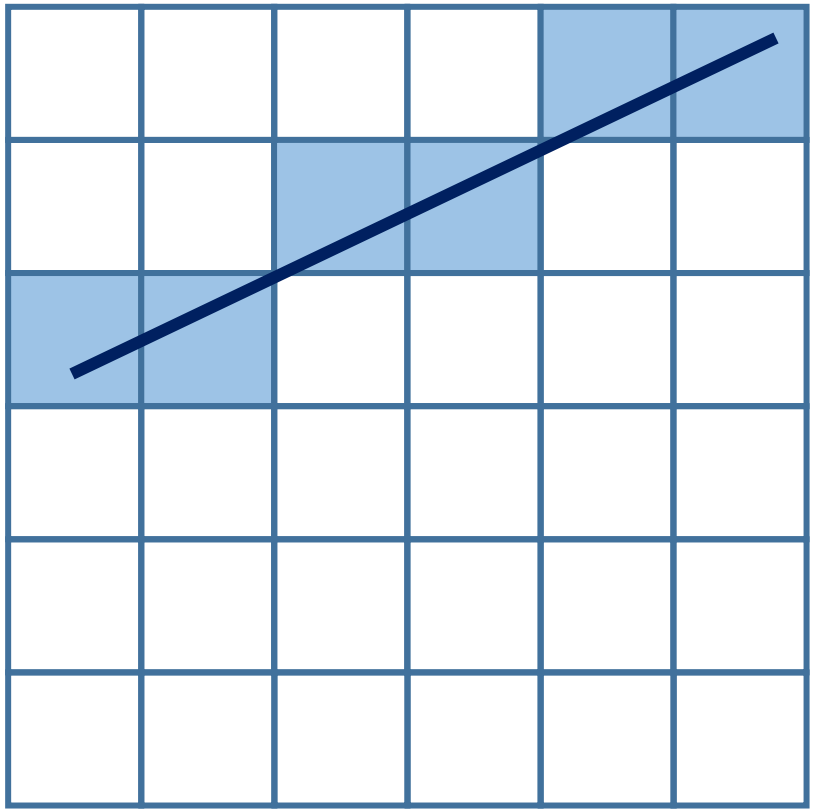
Cut by a factor of 2

Even  or odd

Gives very different results

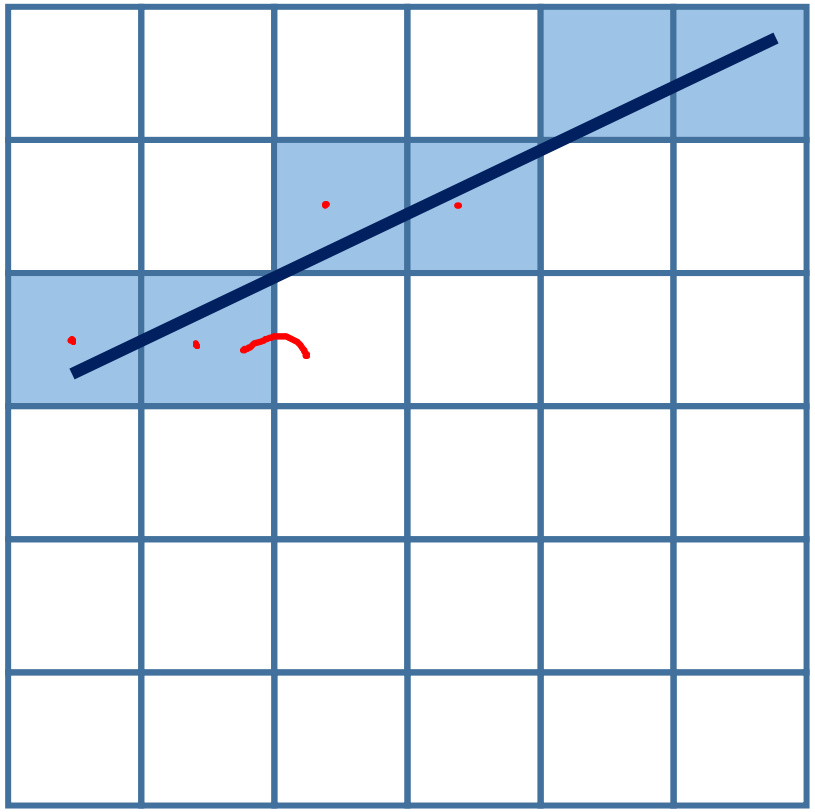


# Lines



# Lines

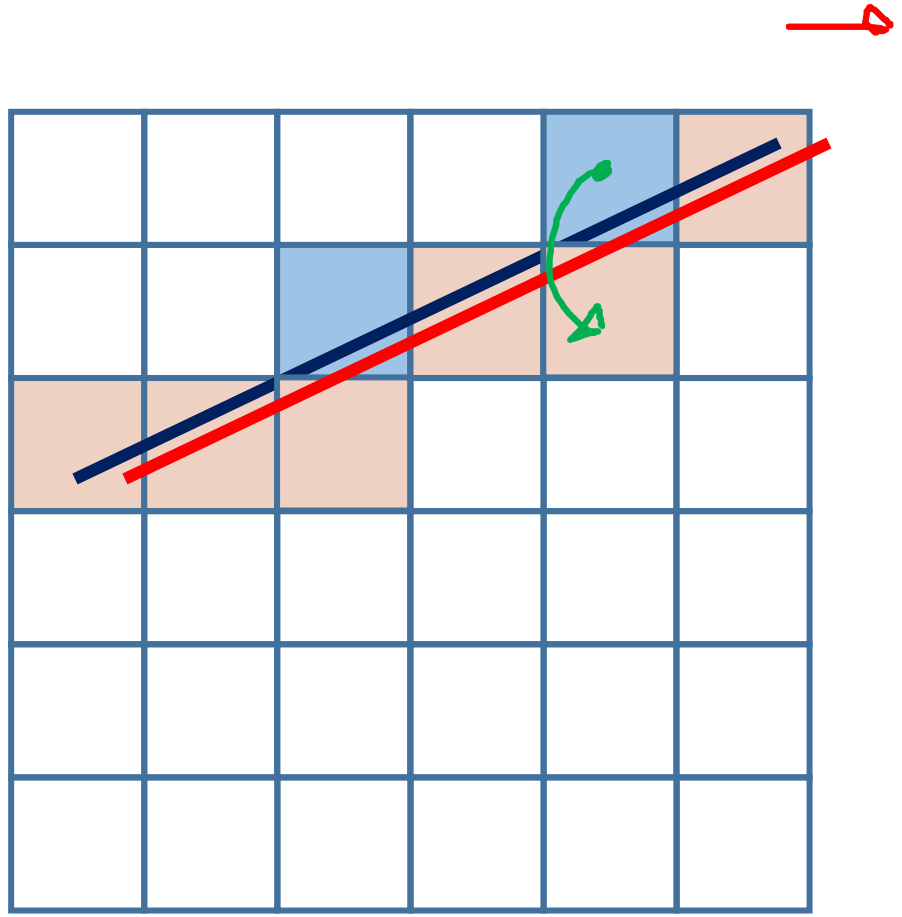
Jaggies



# Lines

Crawlies

(mainly if edge)

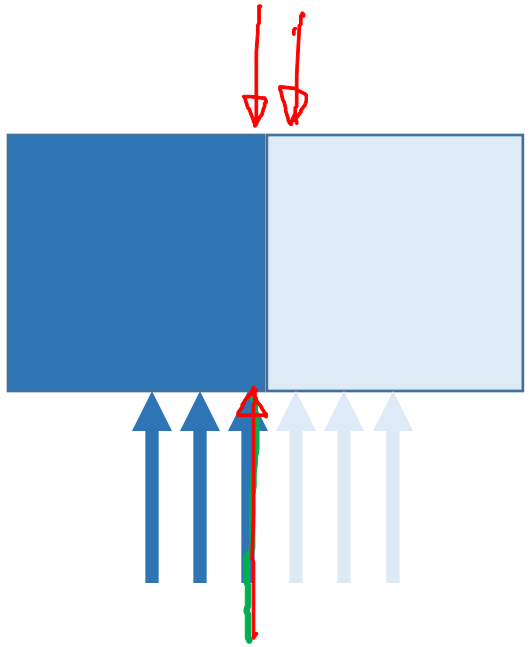


# Intuition: Sharp Edges are bad

Sharp Edge:

Small change in position

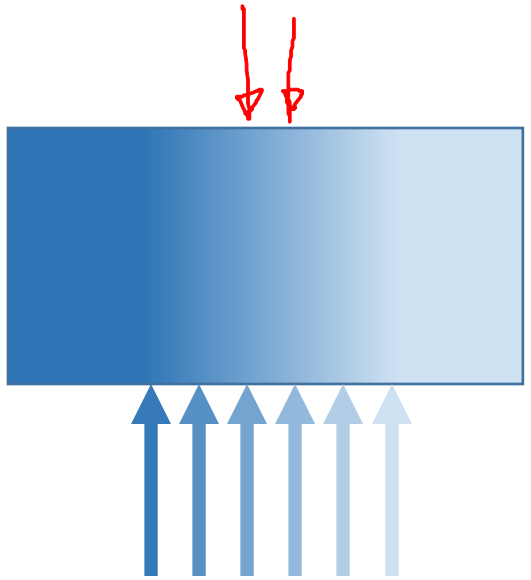
Big change in value



Smoother “Edge:”

Small change in position

Doesn’t matter (that much)

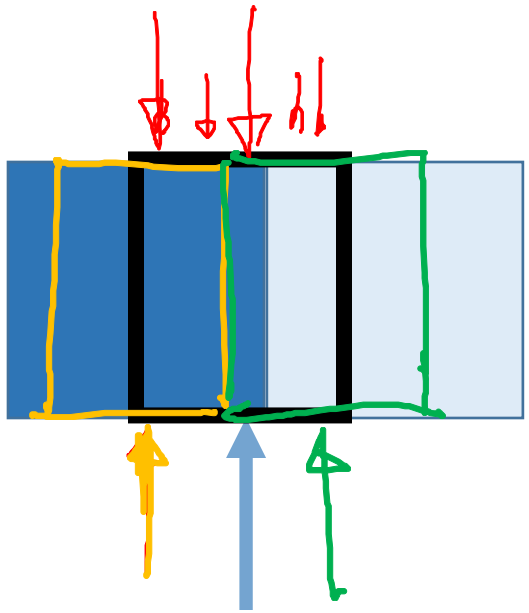


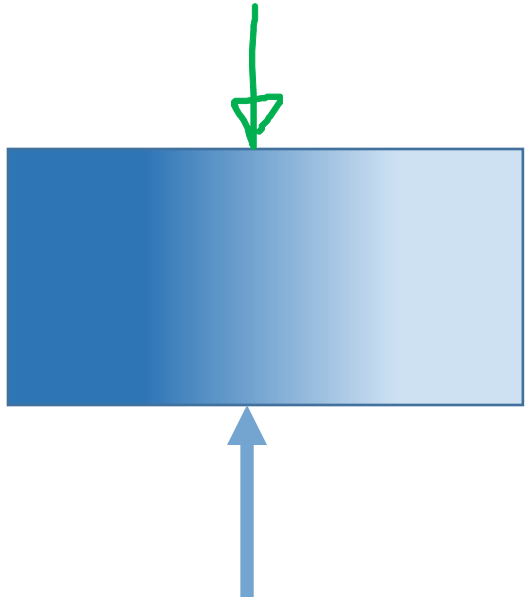
# Idea: Average over the region

Average over the region

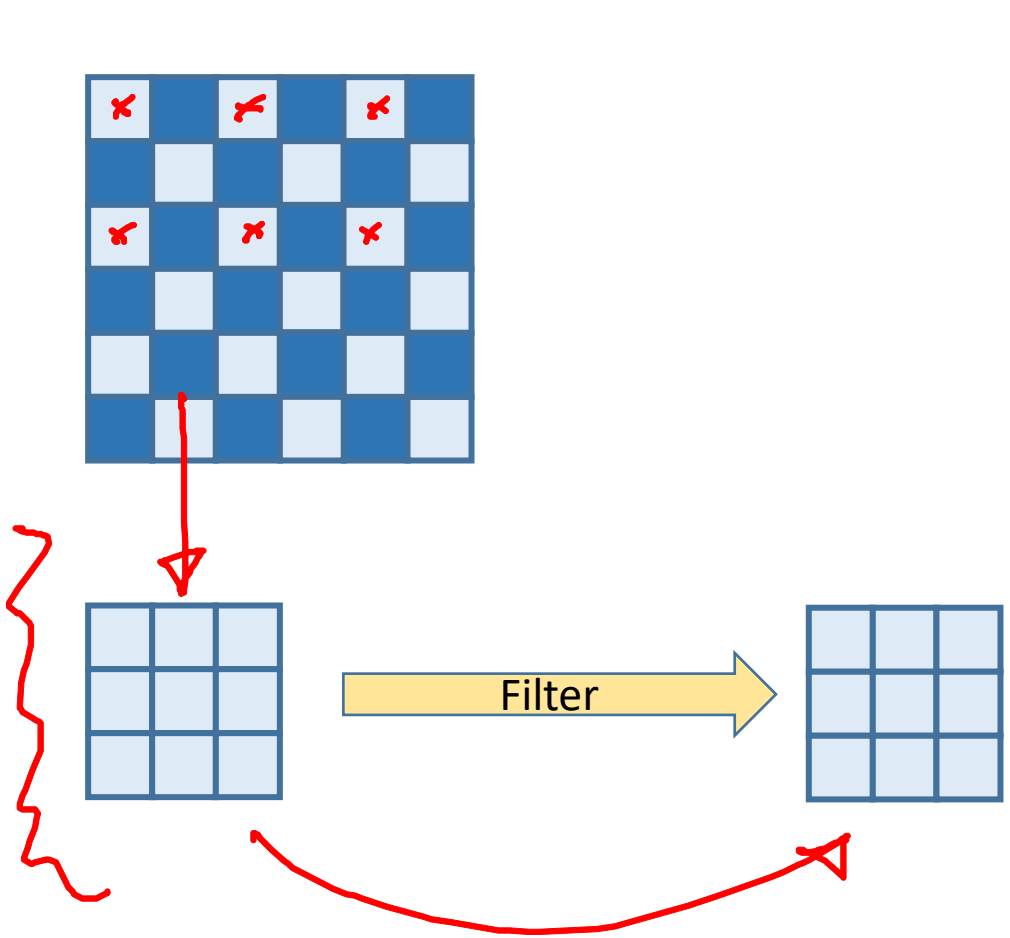
Pre-filter (blur)

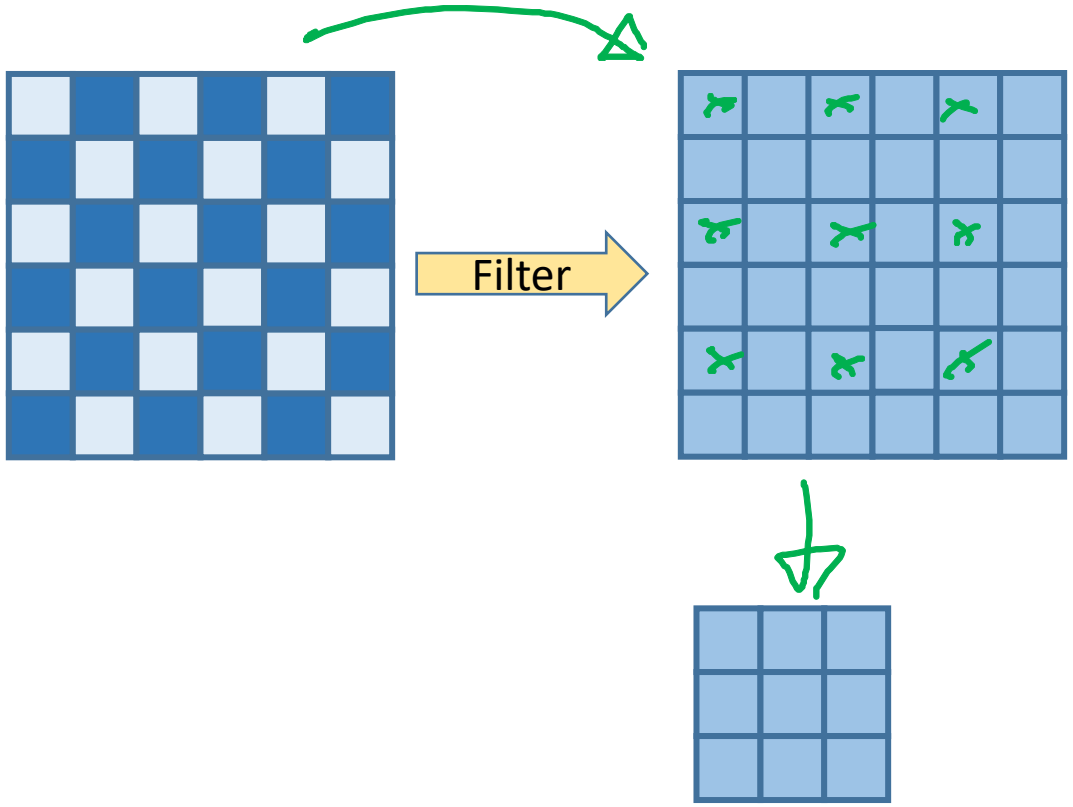
Then point sample





# Important: it is PRE-filtering
# you must filter before Aliasing occurs!



# Anti-Aliasing

You cannot fix aliasing after it happens!

Take steps beforehand to avoid the worst problems

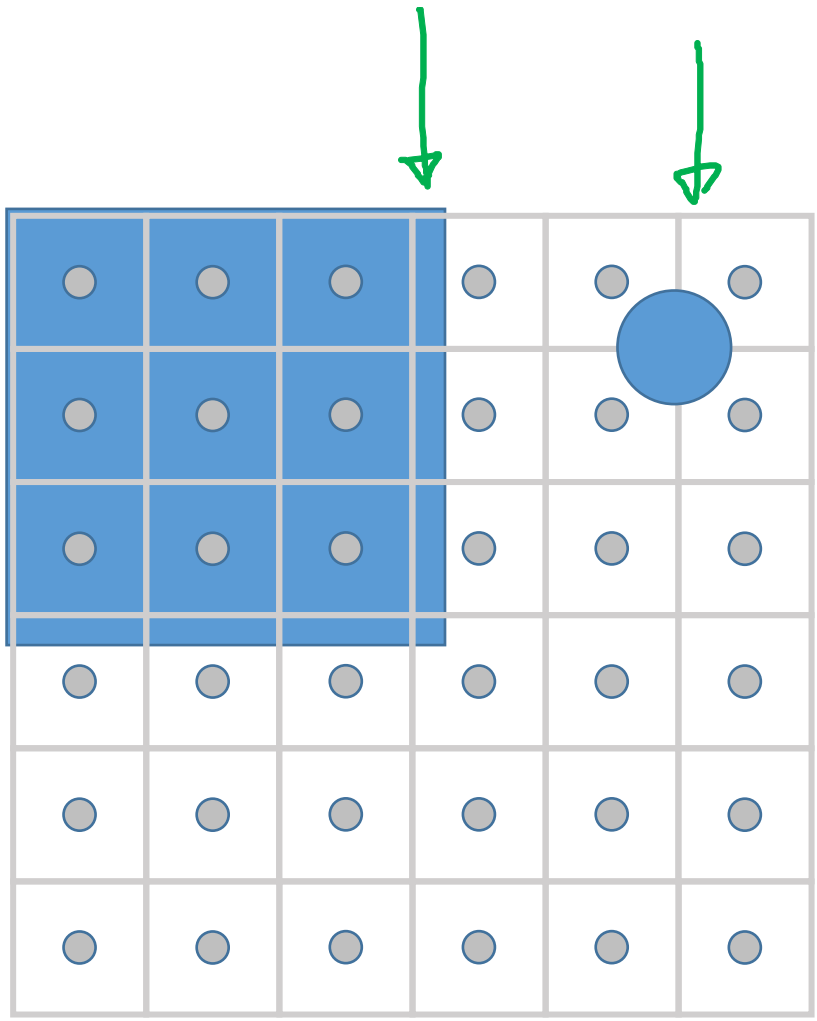
Blurry is better than wrong

# In point sample land

Small things are bad

Sharp edges are bad

Worse when things move



# Blur!

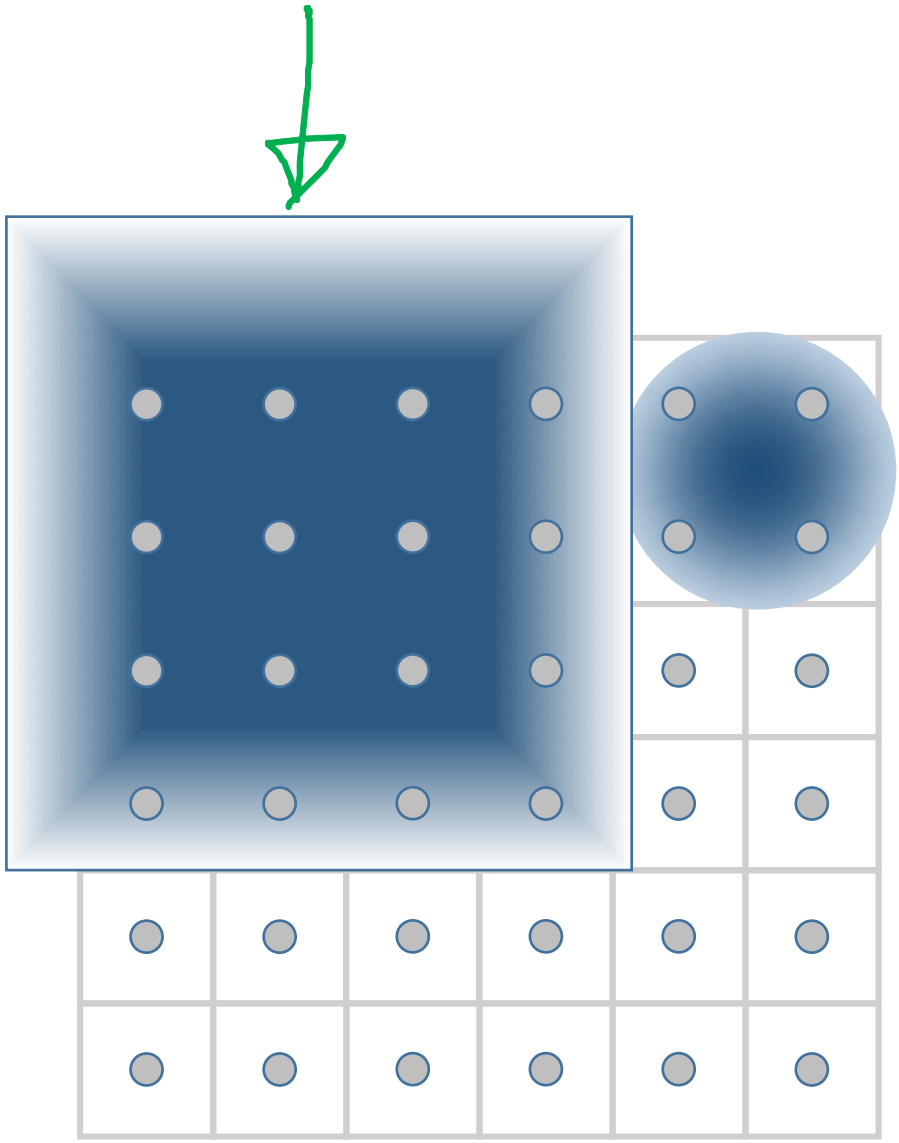
Small things are bad

**Make them bigger!**

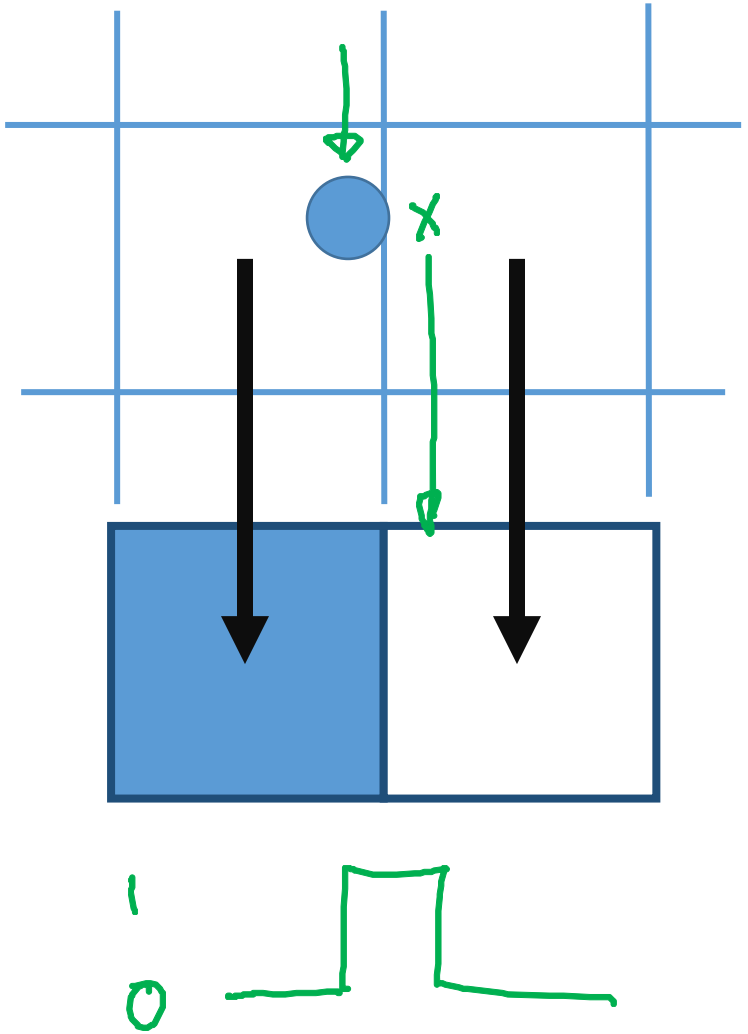
Sharp edges are bad

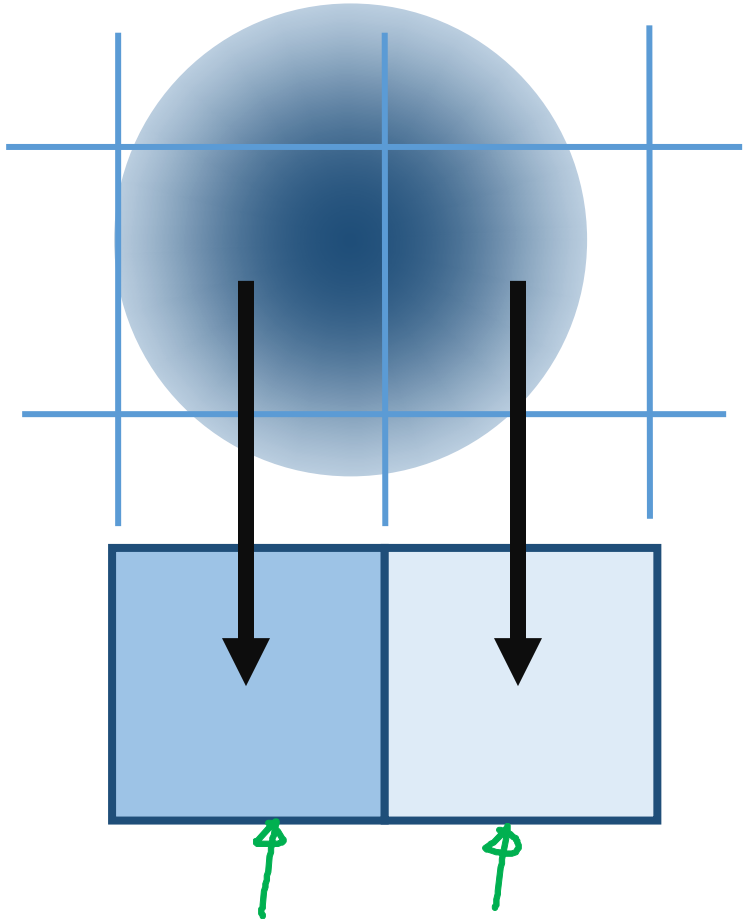
**Make them smooth!**

**Blurry is predictable!**



# How does this help the point problem?



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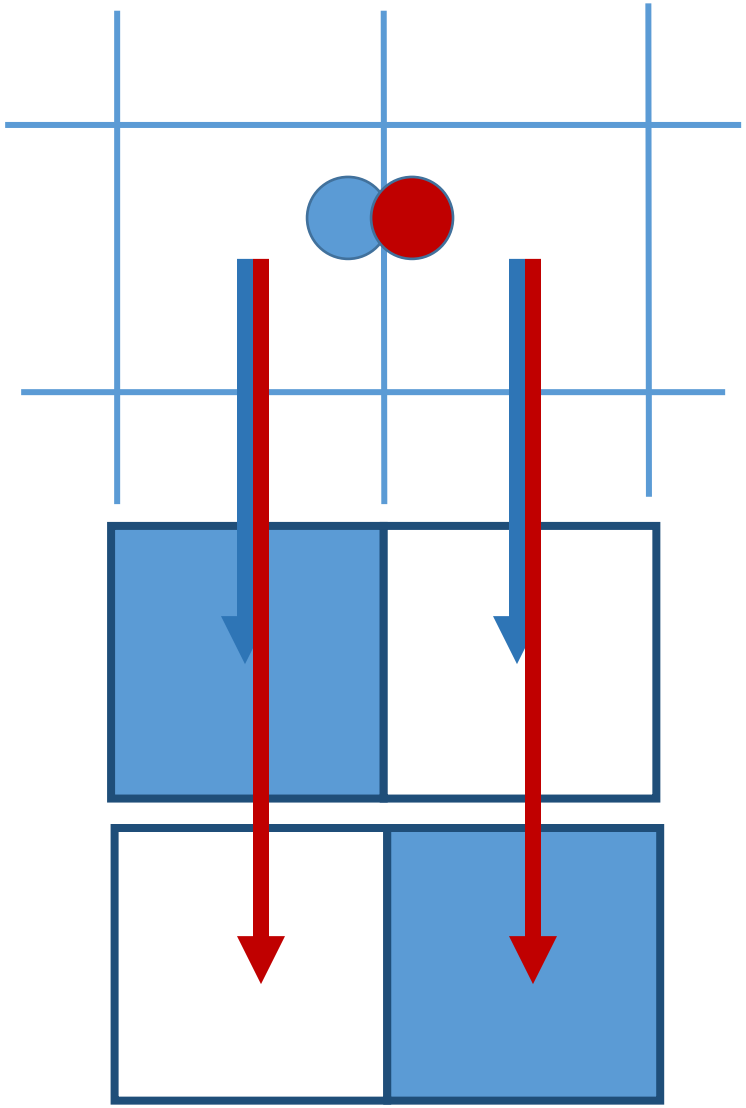
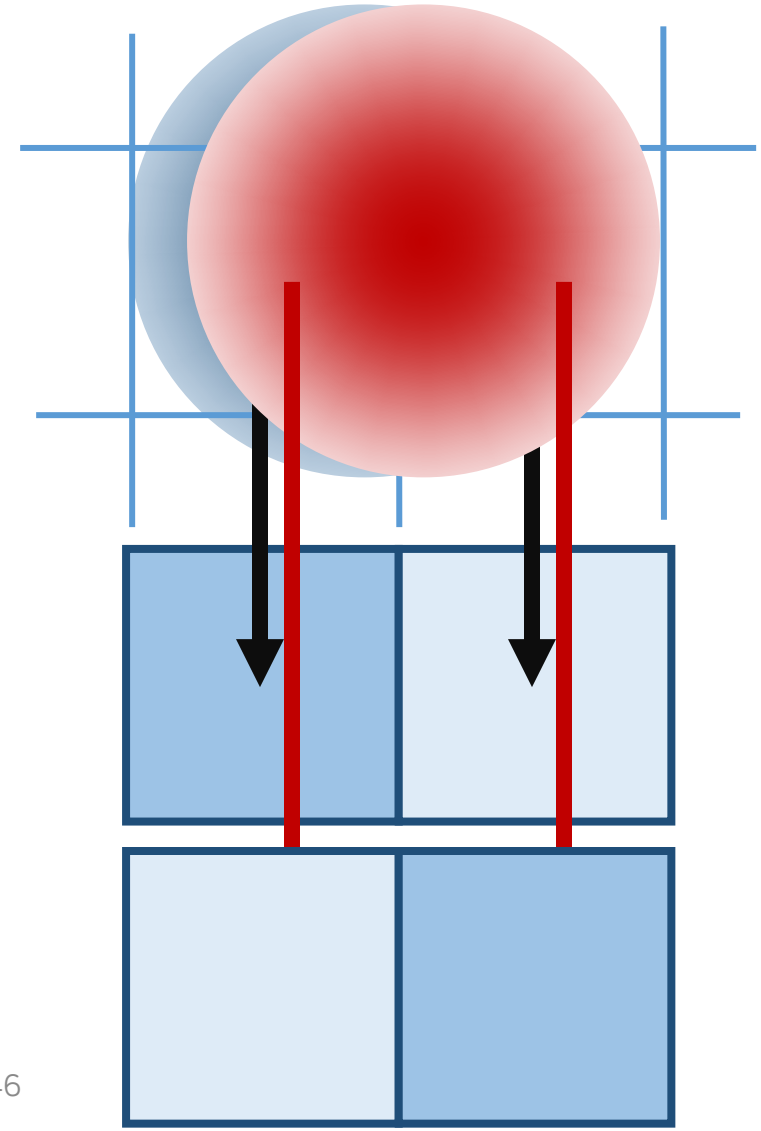


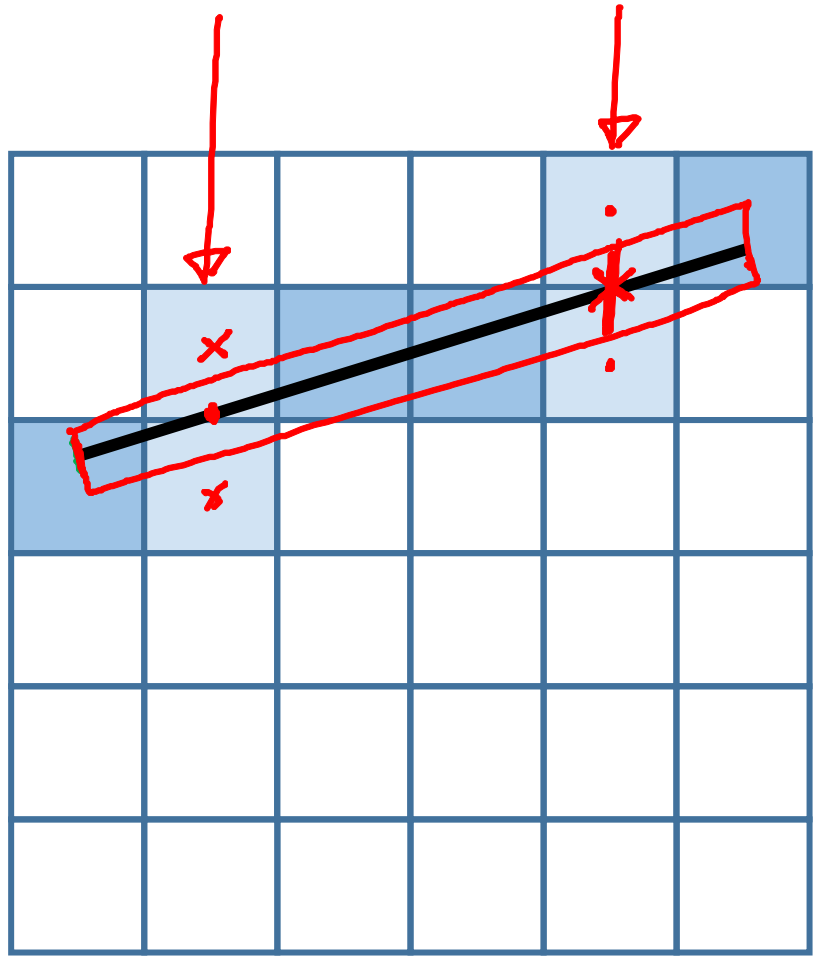


# Lines

Area coverage

thick line

Partial Fill



# Anti-Aliasing Primitives

It can't be a binary yes/no decision

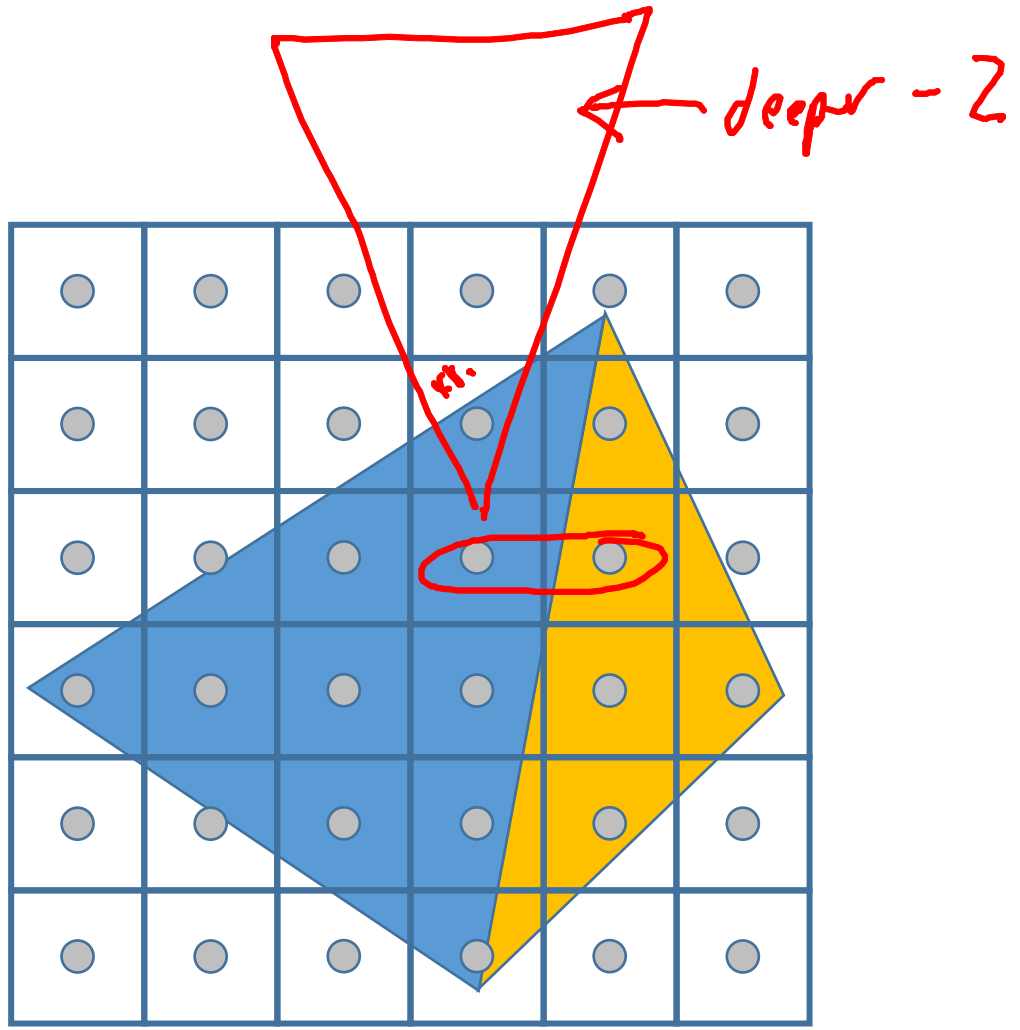
Primitive can partially fill a pixel

Blurred primitive can partially cover the sample point

Problem: what fills the other part?

# Partial Fill and Triangles

A pixel may involve two (or more) triangles!



# Anti-Aliasing Triangle Edges

Have pixels keep track of multiple triangles?

Hard (lots to store per pixel)

We want to keep triangles independent

# Keeping Primitives Independent

Partial fill against background

Alpha channel (transparency)

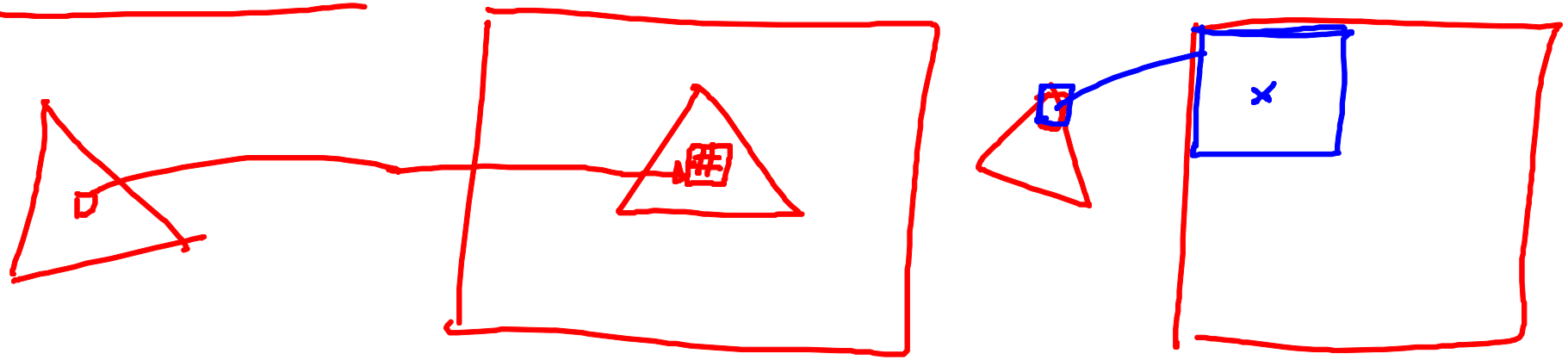
Drawing order matters

# Anti-Aliasing Within a Primitive

Shading computation can be aware of the whole primitive

Fragment shader – can consider an arbitrary range

Image-based shader – can consider a region



# In Practice…

Anti-aliasing triangle edges is problematic

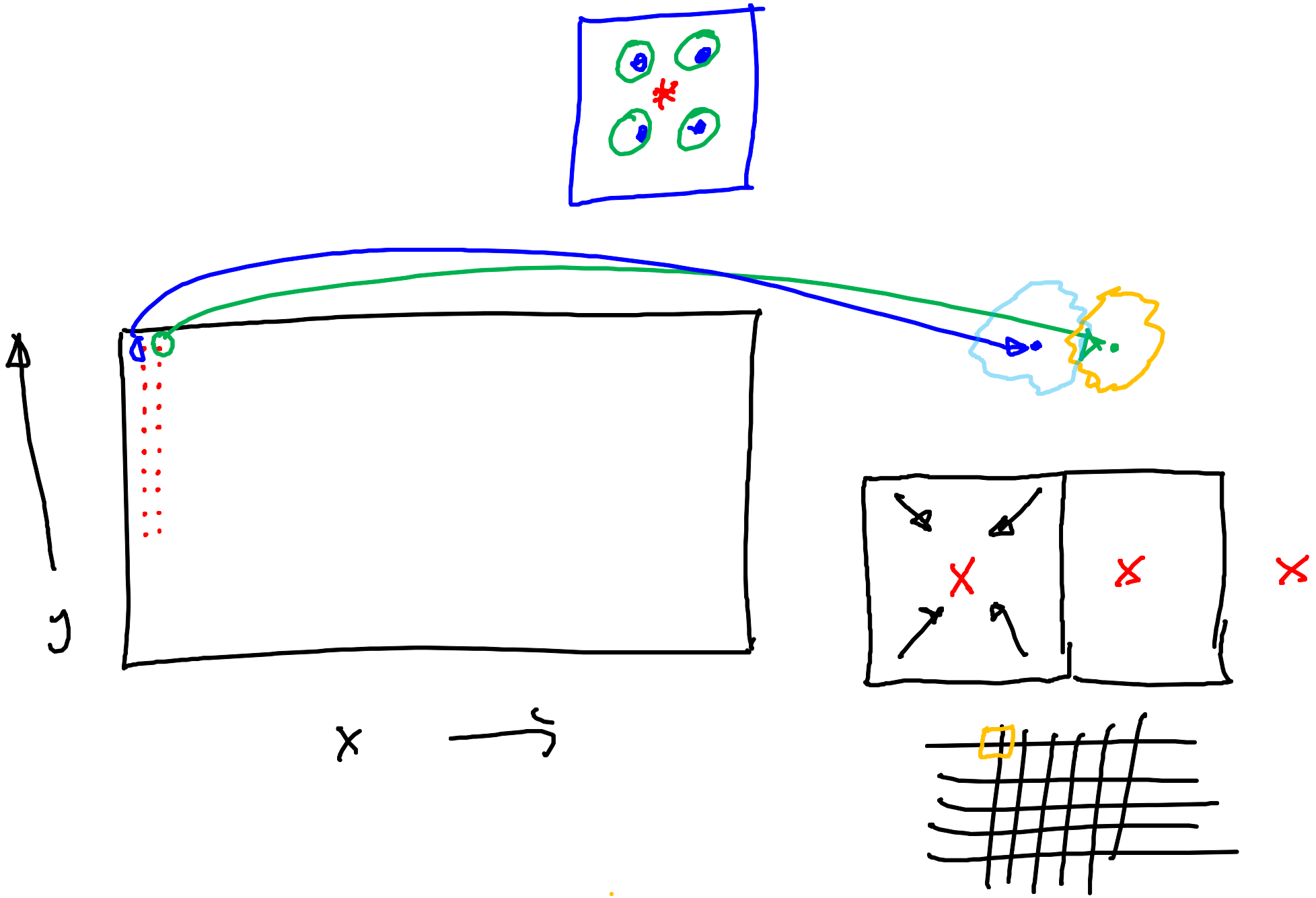
Use transparency (partial filling) when possible

requires back to front (OK for 2D)

Problem is worse when we consider visibility

Textures are easier to filter – use big triangles with texture

High quality rendering considers anti-aliasing


y
x