

# Introduction to Computing and Programming in Python: A Multimedia Approach

## Chapter 4: Modifying Pixels in a Range

# Chapter Learning Goals

**The media learning goals for this chapter are:**

- To mirror pictures horizontally or vertically.
- To compose pictures into one another and create collages.
- To rotate pictures.
- To scale pictures smaller and larger.

**The computer science goals for this chapter are:**

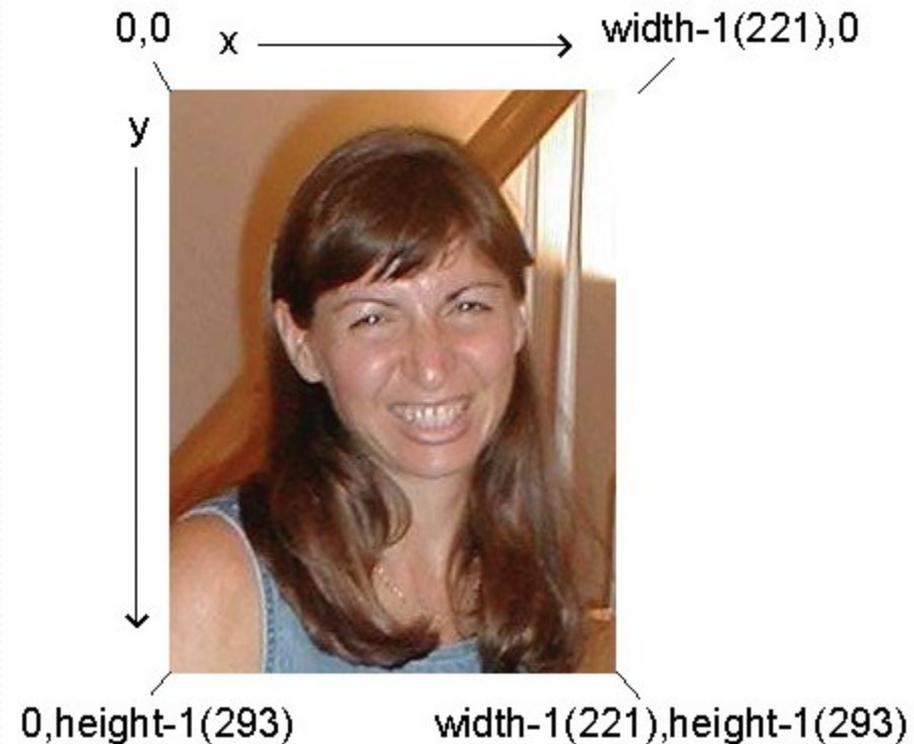
- To use nested loops for addressing elements of a matrix.
- To loop through only part of an array.
- To develop some debugging strategies—specifically, to use print statements to explore executing code.

## Reminder: Pixels are in a matrix

- Matrices have two dimensions: A height and a width
- We can reference any element in the matrix with (x,y) or (horizontal, vertical)
  - We refer to those coordinates as *index numbers* or *indices*
- We sometimes want to know *where* a pixel is, and **getPixels** doesn't let us know that.

# Pixels in a Matrix

- “Barbara.jpg” has
  - height 293 (bottommost index is 292) and
  - width 221 (rightmost index is 220)



# Introducing the function range

- Range returns a sequence between its first two inputs, possibly using a third input as the increment

```
>>> print range(1,4)
[1, 2, 3]
>>> print range(-1,3)
[-1, 0, 1, 2]
>>> print range(1,10,2)
[1, 3, 5, 7, 9]
>>> print range(3)
[0,1,2]
```

## Notice:

- End value is never included.
  - range(0,10) ends at 9.
- If you leave out a start value, it's assumed to be zero.

## Side Note:

That thing in [] is a sequence

```
>>> a=[1,2,3]
```

```
>>> print a
```

```
[1, 2, 3]
```

```
>>> a = a + 4
```

**An attempt was made to call a function with a parameter of an invalid type**

```
>>> a = a + [4]
```

```
>>> print a
```

```
[1, 2, 3, 4]
```

```
>>> a[0]
```

```
1
```

We can assign names to sequences, print them, add items to sequences, and access individual pieces of them.

We can also use **for** loops to process each element of a sequence.

# We can use range to generate index numbers

- We'll do this by working the range from 0 to the height-1, and 0 to the width-1.
  - Using the range function will make it easy to start from 0 and stop before the end value.
- But we'll need more than one loop.
  - Each for loop can only change one variable, and we need two for indexing a matrix

# Working the pixels by number

- To use **range**, we'll have to use *nested loops*
  - One to walk the width, the other to walk the height
    - Be sure to watch your blocks (i.e., indentation) carefully!

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```

# What's going on here?

**The first time through the first loop, x is the name for 0.**

**We'll be processing the first column of pixels in the picture.**

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```

# Now, the inner loop

**Next, we set y to 0.  
We're now going to  
process each of the  
pixels in the first  
column.**

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```

# Process a pixel

**With  $x = 0$  and  $y = 0$ , we get the leftmost pixel and increase its red by 10%**

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```



# Next pixel

**Next we set y to 1 (next value in the sequence *range(0,getHeight(picture))*)**

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```

# Process pixel (0,1)

**x is still 0, and now y is 1, so increase the red for pixel (0,1)**

```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```



**We continue along this way, with y taking on every value from 0 to the height of the picture (minus 1).**

# Finally, next column

**Now that we're done with the loop for y, we get back to the FOR loop for x. x takes on the value 1, and we go back to the y loop to process all the pixels in the column x=1.**

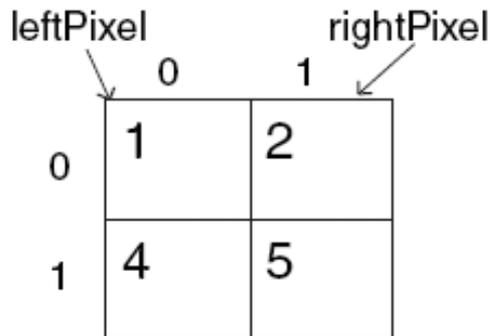
```
def increaseRed2(picture):  
    for x in range(0,getWidth(picture)):  
        for y in range(0,getHeight(picture)):  
            px = getPixel(picture,x,y)  
            value = getRed(px)  
            setRed(px,value*1.1)
```

## What can you do if you know where the pixels are? One answer: Mirroring

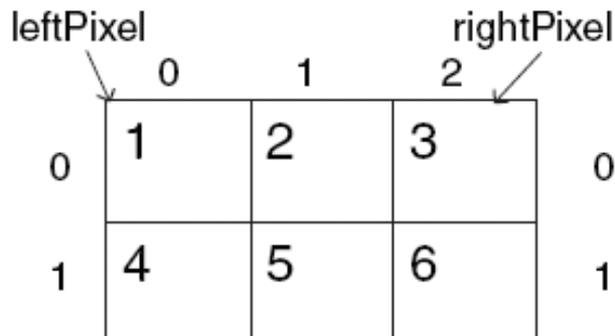
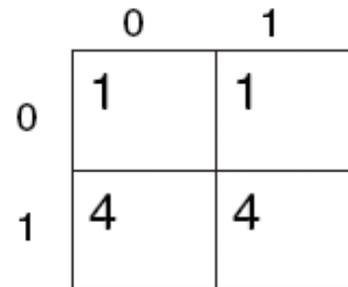
- Imagine a mirror horizontally across the picture, or vertically
- What would we see?
- How do generate that digitally?
  - We simply *copy* the colors of pixels from one place to another

# Work it out with matrices

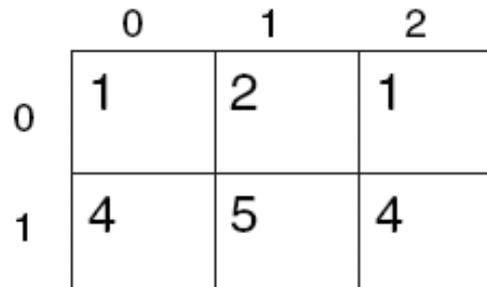
- mirrorPoint is halfway across:  $\text{getWidth}(\text{picture})/2$



$$\text{mirrorPoint} = 2 / 2 = 1$$



$$\text{mirrorPoint} = 3 / 2 = 1$$



**If left pixel is at  $(x,y)$ , right pixel is at  $(\text{width}-x-1,y)$**

# Recipe for mirroring



```
def mirrorVertical(source):  
    mirrorPoint = getWidth(source) / 2  
    width = getWidth(source)  
    for y in range(0,getHeight(source)):  
        for x in range(0,mirrorPoint):  
            leftPixel = getPixel(source,x,y)  
            rightPixel = getPixel(source,width - x - 1,y)  
            color = getColor(leftPixel)  
            setColor(rightPixel,color)
```

Can we do it with a horizontal mirror?

```
def mirrorHorizontal(source):  
    mirrorPoint = getHeight(source) / 2  
    height = getHeight(source)  
    for x in range(0,getWidth(source)):  
        for y in range(0,mirrorPoint):  
            topPixel = getPixel(source,x,y)  
            bottomPixel = getPixel(source,x,height - y - 1)  
            color = getColor(topPixel)  
            setColor(bottomPixel,color)
```

# Of course!



## What if we wanted to copy bottom to top?

- Very simple: Swap the **order of pixels** in the bottom lines

```
def mirrorBotTop(source):  
    mirrorPoint = getHeight(source) / 2  
    height = getHeight(source)  
    for x in range(0,getWidth(source)):  
        for y in range(0,mirrorPoint):  
            topPixel = getPixel(source,x,y)  
            bottomPixel = getPixel(source,x,height - y - 1)  
            color = getColor(bottomPixel)  
            setColor(topPixel,color)
```

# Mirroring bottom to top



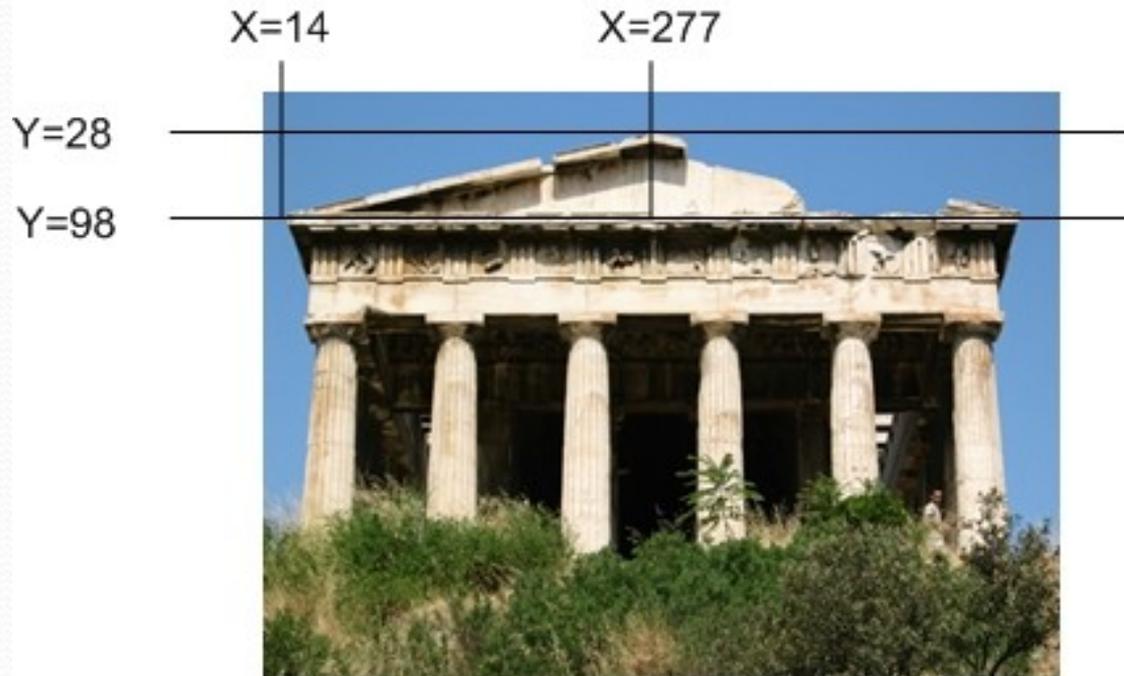
# Doing something useful with mirroring

- Mirroring can be used to create interesting effects, but it can also be used to create realistic effects.
- Consider this image from a trip to Athens, Greece.
  - Can we “repair” the temple by mirroring the complete part onto the broken part?



# Figuring out where to mirror

- Use MediaTools to find the mirror point and the range that we want to copy



# Writing functions for specific files... generally

- The function to mirror the temple needs to work for one and only one file.
- But we still don't want to write out the whole path.
  - `setMediaPath()` allows us to pick a directory where our media will be stored.
  - `getMediaPath(filename)` will *generate* the entire path for us to the filename *in the media directory*
  - *THIS ONLY WORKS WHEN WE'RE ACCESSING FILES IN THE MEDIA DIRECTORY AND WHERE WE HAVE SET THE PATH FIRST!*

# Some Utility Functions

- If you *know* the name of the file, searching for it with **pickAFile()** feels tedious
- You can set and get a media *folder (path)* for remembering a place where your media will be coming from (or going to)
  - **setMediaPath()** lets you pick a file in your media folder
  - **getMediaPath(basefilename)** lets you generate a complete filename out of only the last part

# Example

```
>>> setMediaPath()
```

```
New media folder: C:\Documents and Settings\Mark  
Guzdial\My Documents\mediasources\
```

```
>>> getMediaPath("barbara.jpg")
```

```
'C:\\Documents and Settings\\Mark Guzdial\\My  
Documents\\mediasources\\barbara.jpg'
```

```
>>> barb=makePicture(getMediaPath("barbara.jpg"))
```

# Program to mirror the temple

```
def mirrorTemple():  
    source = makePicture(getMediaPath("temple.jpg"))  
    mirrorPoint = 276  
    for x in range(13,mirrorPoint):  
        for y in range(27,97):  
            pleft = getPixel(source,x,y)  
            pright = getPixel(source,mirrorPoint + mirrorPoint - 1 - x,y)  
            setColor(pright,getColor(pleft))  
    show(source)  
    return source
```

# Did it really work?

- It clearly did the mirroring, but that doesn't create a 100% realistic image.
- Check out the shadows: Which direction is the sun coming from?



# Understanding the Temple Fix

- What is the very first transfer of pixels from and to?  
Which  $(x,y)$  pixel from? Which  $(x,y)$  pixel to?
- What is second?
- How many pixels get copied?

## Adding print statements to see what's happening

```
def mirrorTemple():
    source = makePicture(getMediaPath("temple.jpg"))
    mirrorPoint = 276
    for x in range(13,mirrorPoint):
        for y in range(27,97):
            print "Copying color from",x,y, " to ",mirrorPoint + mirrorPoint - 1 - x, y
            pleft = getPixel(source,x,y)
            pright = getPixel(source,mirrorPoint + mirrorPoint - 1 - x,y)
            setColor(pright,getColor(pleft))
    show(source)
    return source
```

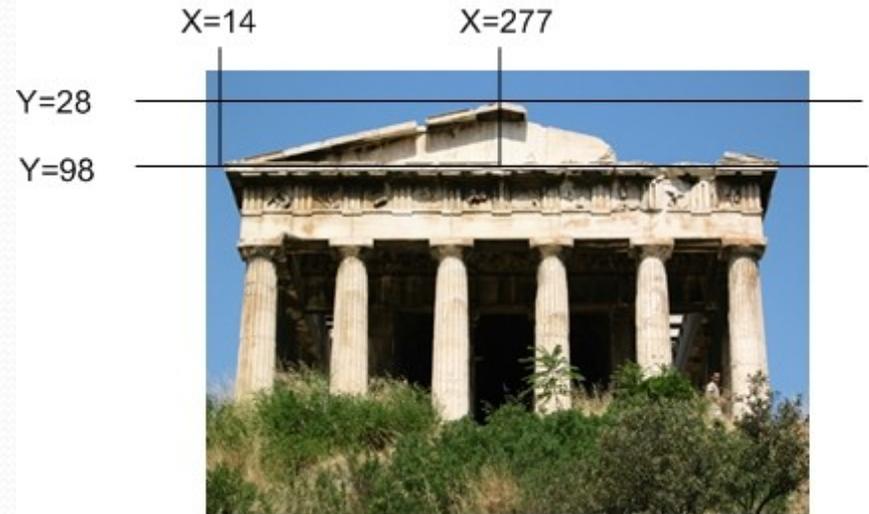
First pixels are either side of the mirrorpoint, then moving down

```
>>> p2=mirrorTemple()
```

Copying color from 13 27  
to 538 27

Copying color from 13 28  
to 538 28

Copying color from 13 29  
to 538 29



# Counting pixels

```
def mirrorTemple():
    source = makePicture(getMediaPath("temple.jpg"))
    mirrorPoint = 276
    count = 0
    for x in range(13,mirrorPoint):
        for y in range(27,97):
            pleft = getPixel(source,x,y)
            pright = getPixel(source,mirrorPoint + mirrorPoint - 1 - x,y)
            setColor(pright,getColor(pleft))
            count = count + 1
    show(source)
    print "We copied",count,"pixels"
    return source
```

# Counting pixels

```
>>> p2=mirrorTemple()  
We copied 18410 pixels
```

- Where did that come from?
  - How many rows? Y goes from 27 to 97
    - = 70 rows of pixels
  - How many columns? X goes from 13 to 276
    - = 263 columns of pixels
  - $70 * 263 = 18410$

# Moving pixels *across* pictures

- We've seen using index variables to track the pixel position we're working with in a picture.
- We can copy *between* pictures, if we keep track of:
  - The *source* index variables
    - Where we're getting the pixels *from*
  - The *target* index variables
    - Where we're putting the pixels *at*
- (Not really copying the pixels: *Replicating* their color.)

# What can you do then?

- What can you do when copying from one picture to another?
  - Collages: Copy *several* pictures onto one
  - Cropping: You don't have to take the *whole* picture
  - Scaling: Make a picture smaller, or larger when copying it

# Blank files in mediasources

- `getMediaPath("7inX95in.jpg")` gives you a JPEG canvas which prints out as 7x9.5 inches
  - Letter-sized page with 1 inch margins
- `getMediaPath("640x480.jpg")` gives a JPEG canvas at a common size: 640 pixels across by 480 pixels high

# Copying pixels

- In general, what we want to do is to keep track of a sourceX and sourceY, and a targetX and targetY.
  - We *increment* (add to them) in pairs
    - sourceX and targetX get incremented together
    - sourceY and targetY get incremented together
  - The tricky parts are:
    - Setting values *inside* the body of loops
    - Incrementing at the *bottom* of loops

# Copying Barb to a canvas

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```



# Comments

- Python ignores from “#” through the rest of the line
- If you start a line with “#”, the whole line is ignored
- Why do we want lines to be *ignored*?
  - To be able to leave notes to ourselves or someone else about how the program works

# Walking through the copying function

- First, get the source (barb) and target (canvas) files and pictures as names we can use later.

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```

# The actual copy

- We get the color of the pixel at sourceX and sourceY
- We set (copy) the color to the pixel in the target picture at targetX and targetY

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
  
        show(barb)  
    show(canvas)  
    return canvas
```

# Setting up the copy loop

- targetX gets set to 0 at the beginning
- sourceX will range across the width of the source picture
- *INSIDE* the loop, we set targetY to 0
  - *Inside* because we want it to start at 0 each time we do a new X
- sourceY will range from 0 to one less height of source

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```

# Ending the loop

- Just before we end the sourceY loop, we increment targetY
  - **It's now set up for the next time through the loop**
  - **It's set correctly for the next value of sourceY**
- Just before we end the sourceX loop, we increment the targetX
  - **Note carefully the indentation to figure out which goes with which loop**

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
        show(barb)  
    show(canvas)  
    return canvas
```

# What's this naming something as itself?

- **targetX = targetX + 1**
- This isn't really naming something as itself
  - targetX + 1 is *evaluated*
    - It will result in the number after targetX
  - targetX = then sets the value of targetX
- The result is that targetX gets incremented by 1

# Ending the copy function

- At the very end, we show the source and target
- And return the modified target.

```
def copyBarb():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
        targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```

# Works either way

```
def copyBarb2():
    # Set up the source and target pictures
    barbf=getMediaPath("barbara.jpg")
    barb = makePicture(barbf)
    canvasf = getMediaPath("7inX95in.jpg")
    canvas = makePicture(canvasf)
    # Now, do the actual copying
    sourceX = 0
    for targetX in range(0,getWidth(barb)):
        sourceY = 0
        for targetY in range(0,getHeight(barb)):
            color =
            getColor(getPixel(barb,sourceX,sourceY))
            setColor(getPixel(canvas,targetX,targetY), color)
            sourceY = sourceY + 1
            sourceX = sourceX + 1
        show(barb)
    show(canvas)
    return canvas
```

**As long as we increment sourceX and targetX together, and sourceY and targetY together, it doesn't matter which is in the for loop and which is incremented via expression**

## Transformation = Small changes in copying

- Making relatively small changes in this basic copying program can make a variety of transformations.
  - Change the targetX and targetY, and you copy wherever you want
  - **Cropping:** Change the sourceX and sourceY range, and you copy only part of the program.
  - **Rotating:** Swap targetX and targetY, and you end up copying sideways
  - **Scaling:** Change the increment on sourceX and sourceY, and you either grow or shrink the image.

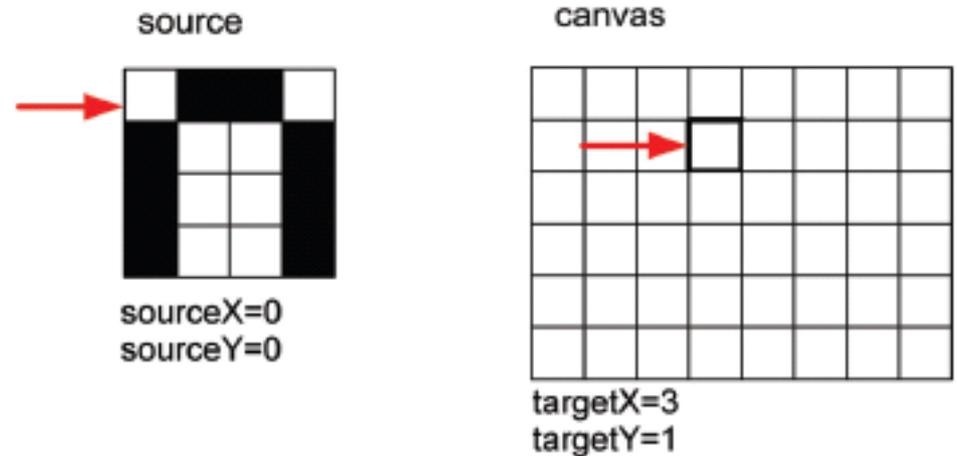
# Copying into the middle of the canvas

```
def copyBarbMidway():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 100  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 100  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
        targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```



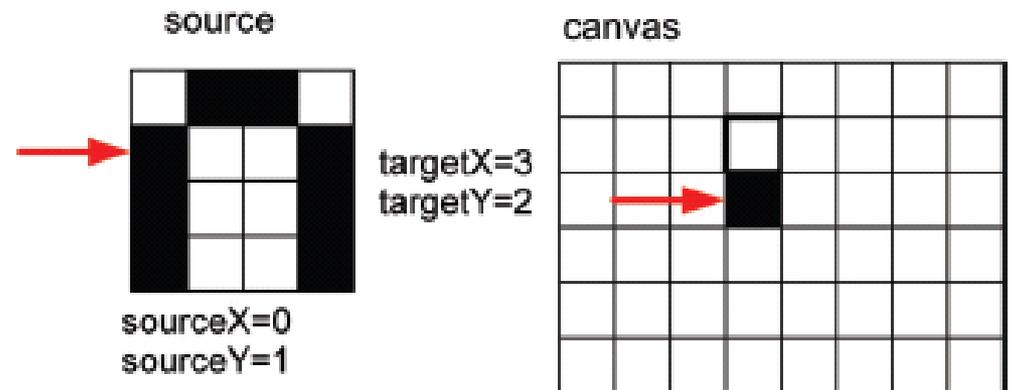
# Copying: How it works

- Here's the initial setup:



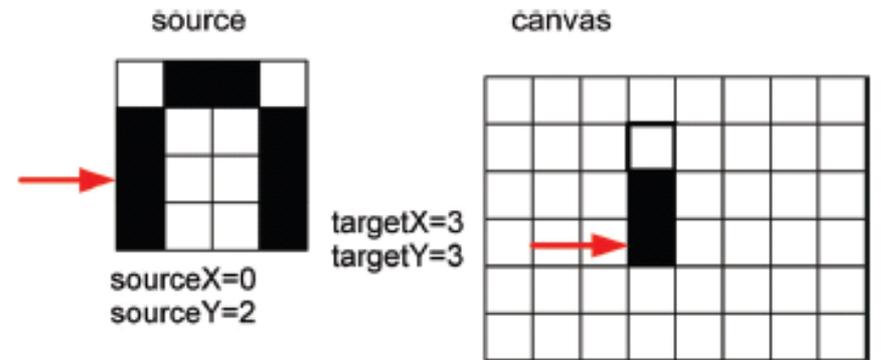
# Copying: How it works 2

- After incrementing the sourceY and targetY once (whether in the **for** or via expression):



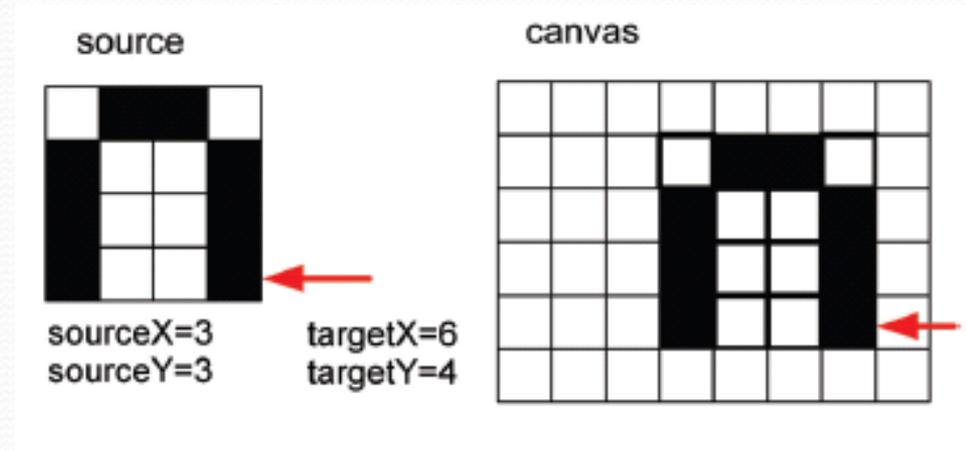
# Copying: How it works 3

- After yet another increment of sourceY and targetY:
- When we finish that column, we increment sourceX and targetX, and start on the next column.



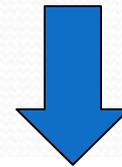
## Copying: How it looks at the end

- Eventually, we copy every pixel



# Making a collage

- Could we do something to the pictures we copy in?
  - Sure! Could either apply one of those functions *before* copying, or do something to the pixels *during* the copy.
- Could we copy more than one picture!
  - Of course! Make a collage!



```

def createCollage():
    flower1=makePicture(getMediaPath("flower1.jpg"))
    print flower1
    flower2=makePicture(getMediaPath("flower2.jpg"))
    print flower2
    canvas=makePicture(getMediaPath("640x480.jpg"))
    print canvas
    #First picture, at left edge
    targetX=0
    for sourceX in range(0,getWidth(flower1)):
        targetY=getHeight(canvas)-getHeight(flower1)-5
        for sourceY in range(0,getHeight(flower1)):
            px=getPixel(flower1,sourceX,sourceY)
            cx=getPixel(canvas,targetX,targetY)
            setColor(cx,getColor(px))
            targetY=targetY + 1
            targetX=targetX + 1
    #Second picture, 100 pixels over
    targetX=100
    for sourceX in range(0,getWidth(flower2)):
        targetY=getHeight(canvas)-getHeight(flower2)-5
        for sourceY in range(0,getHeight(flower2)):
            px=getPixel(flower2,sourceX,sourceY)
            cx=getPixel(canvas,targetX,targetY)
            setColor(cx,getColor(px))
            targetY=targetY + 1
            targetX=targetX + 1

```

```

#Third picture, flower1 negated
negative(flower1)
targetX=200
for sourceX in range(0,getWidth(flower1)):
    targetY=getHeight(canvas)-getHeight(flower1)-5
    for sourceY in range(0,getHeight(flower1)):
        px=getPixel(flower1,sourceX,sourceY)
        cx=getPixel(canvas,targetX,targetY)
        setColor(cx,getColor(px))
        targetY=targetY + 1
        targetX=targetX + 1
#Fourth picture, flower2 with no blue
clearBlue(flower2)
targetX=300
for sourceX in range(0,getWidth(flower2)):
    targetY=getHeight(canvas)-getHeight(flower2)-5
    for sourceY in range(0,getHeight(flower2)):
        px=getPixel(flower2,sourceX,sourceY)
        cx=getPixel(canvas,targetX,targetY)
        setColor(cx,getColor(px))
        targetY=targetY + 1
        targetX=targetX + 1
#Fifth picture, flower1, negated with decreased red
decreaseRed(flower1)
targetX=400
for sourceX in range(0,getWidth(flower1)):
    targetY=getHeight(canvas)-getHeight(flower1)-5
    for sourceY in range(0,getHeight(flower1)):
        px=getPixel(flower1,sourceX,sourceY)
        cx=getPixel(canvas,targetX,targetY)
        setColor(cx,getColor(px))
        targetY=targetY + 1
        targetX=targetX + 1
show(canvas)
return(canvas)

```

# Can we make that easier?

- The collage code is long, yet simple.
- It's the same thing over-and-over.
- We can *generalize* that copying loop, and with *parameters*, use it in many places.

```
def copy(source, target, targX, targY):
    targetX = targX
    for sourceX in range(0,getWidth(source)):
        targetY = targY
        for sourceY in
            range(0,getHeight(source)):
            px=getPixel(source,sourceX,sourceY)
            tx=getPixel(target,targetX,targetY)
            setColor(tx,getColor(px))
            targetY=targetY + 1
            targetX=targetX + 1
```

# Exact same collage!

```
def createCollage2():  
  
    flower1=makePicture(getMediaPath("flower1.jpg"))  
    print flower1  
  
    flower2=makePicture(getMediaPath("flower2.jpg"))  
    print flower2  
  
    canvas=makePicture(getMediaPath("640x480.jpg"))  
    print canvas  
    #First picture, at left edge  
    copy(flower1,canvas,0,getHeight(canvas)-getHeight(flower1)-5)  
    #Second picture, 100 pixels over  
  
    copy(flower2,canvas,100,getHeight(canvas)-getHeight(flower2)-5)
```

```
#Third picture, flower1 negated  
negative(flower1)  
  
copy(flower1,canvas,200,getHeight(canvas)-getHeight(flower1)-5)  
#Fourth picture, flower2 with no blue  
clearBlue(flower2)  
  
copy(flower2,canvas,300,getHeight(canvas)-getHeight(flower2)-5)  
#Fifth picture, flower1, negated with decreased red  
decreaseRed(flower1)  
  
copy(flower1,canvas,400,getHeight(canvas)-getHeight(flower2)-5)  
return canvas
```

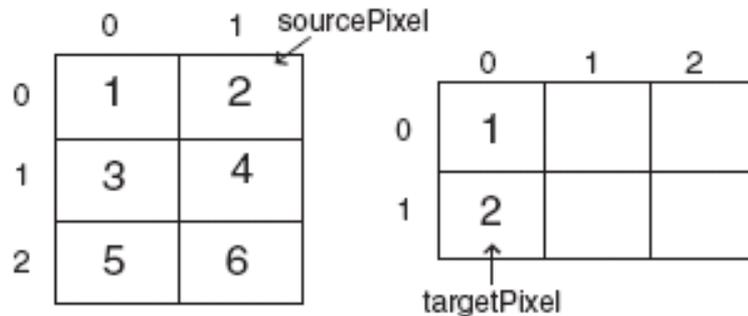
# Rotating the copy

```
def copyBarbSideways():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 0  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetY,targetX), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```



# Rotating: How it works

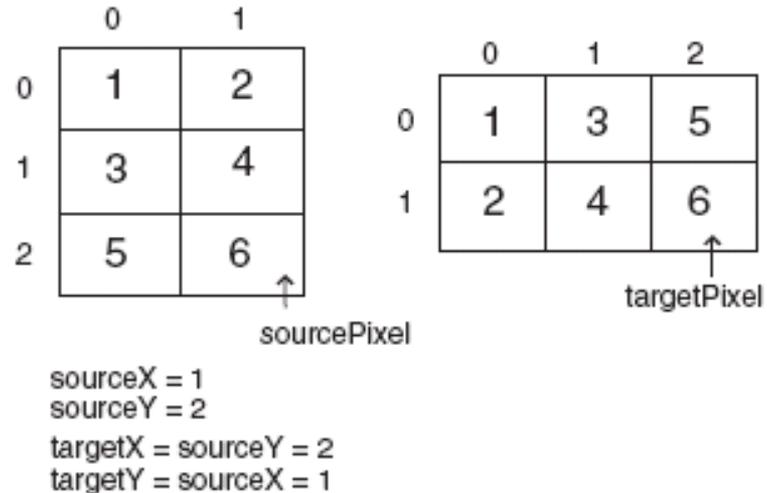
- We increment the same, but we use **targetX** for the *Y coordinate* and **targetY** for the *X coordinate*



sourceX = 0  
sourceY = 1  
targetX = sourceY = 1  
targetY = sourceX = 0

# Rotate: How it ends

- Same amount of increment, even same values in the variables, but a different result.



# Doing a *real* rotation

```
def rotateBarbSideways():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 0  
    width = getWidth(barb)  
    for sourceX in range(0,getWidth(barb)):  
        targetY = 0  
        for sourceY in range(0,getHeight(barb)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetY,width - targetX  
- 1), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
        show(barb)  
    show(canvas)  
    return canvas
```

# Cropping: Just the face

```
def copyBarbsFace():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    targetX = 100  
    for sourceX in range(45,200):  
        targetY = 100  
        for sourceY in range(25,200):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            targetY = targetY + 1  
            targetX = targetX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```



# Cropping, another way

```
def copyBarbsFace2():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    sourceX = 45  
    for targetX in range(100,100+(200-45)):  
        sourceY = 25  
        for targetY in range(100,100+(200-25)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            sourceY = sourceY + 1  
            sourceX = sourceX + 1  
    show(barb)  
    show(canvas)  
    return canvas
```

# Scaling

- Scaling a picture (smaller or larger) has to do with *sampling* the source picture differently
  - When we just copy, we *sample* every pixel
  - If we want a smaller copy, we skip some pixels
    - We *sample* fewer pixels
  - If we want a larger copy, we duplicate some pixels
    - We *over-sample* some pixels

# Scaling the picture down

```
def copyBarbsFaceSmaller():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    sourceX = 45  
    for targetX in range(100,100+((200-45)/2)):  
        sourceY = 25  
        for targetY in range(100,100+((200-25)/2)):  
            color = getColor(getPixel(barb,sourceX,sourceY))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            sourceY = sourceY + 2  
            sourceX = sourceX + 2  
    show(barb)  
    show(canvas)  
    return canvas
```



# Scaling Up: Growing the picture

- To grow a picture, we simply duplicate some pixels
- We do this by incrementing by 0.5, but only use the integer part.

```
>>> print int(1)
1
>>> print int(1.5)
1
>>> print int(2)
2
>>> print int(2.5)
2
```

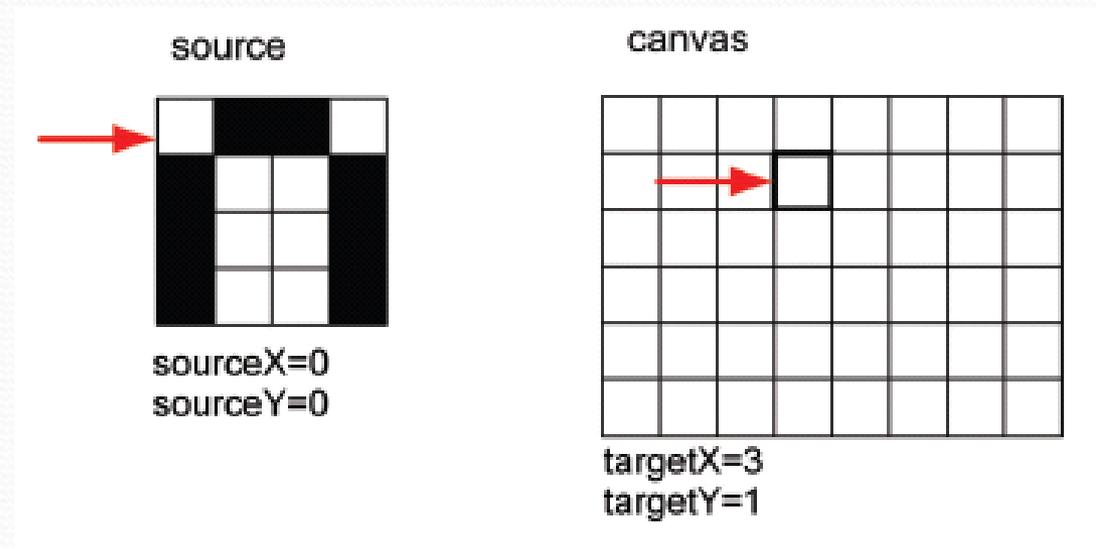
# Scaling the picture up

```
def copyBarbsFaceLarger():  
    # Set up the source and target pictures  
    barbf=getMediaPath("barbara.jpg")  
    barb = makePicture(barbf)  
    canvasf = getMediaPath("7inX95in.jpg")  
    canvas = makePicture(canvasf)  
    # Now, do the actual copying  
    sourceX = 45  
    for targetX in range(100,100+((200-45)*2)):  
        sourceY = 25  
        for targetY in range(100,100+((200-25)*2)):  
            color = getColor(getPixel(barb,int(sourceX),int(sourceY)))  
            setColor(getPixel(canvas,targetX,targetY), color)  
            sourceY = sourceY + 0.5  
            sourceX = sourceX + 0.5  
    show(barb)  
    show(canvas)  
    return canvas
```



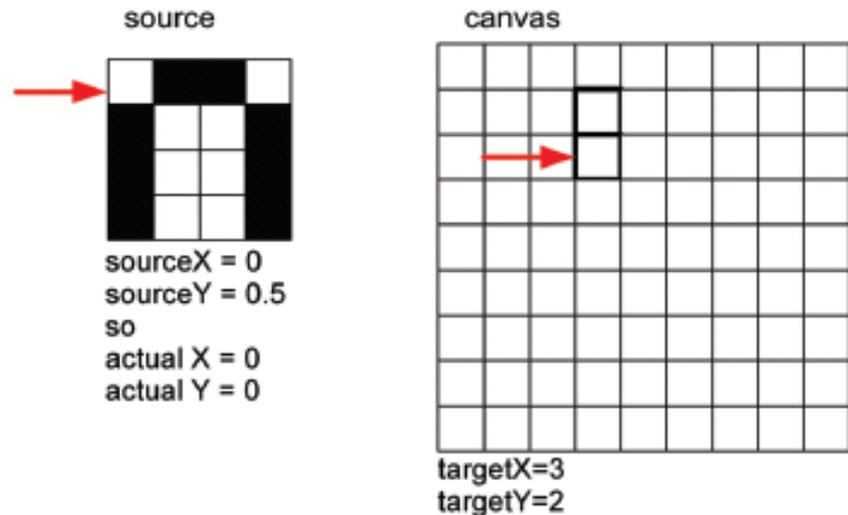
# Scaling up: How it works

- Same basic setup as copying and rotating:



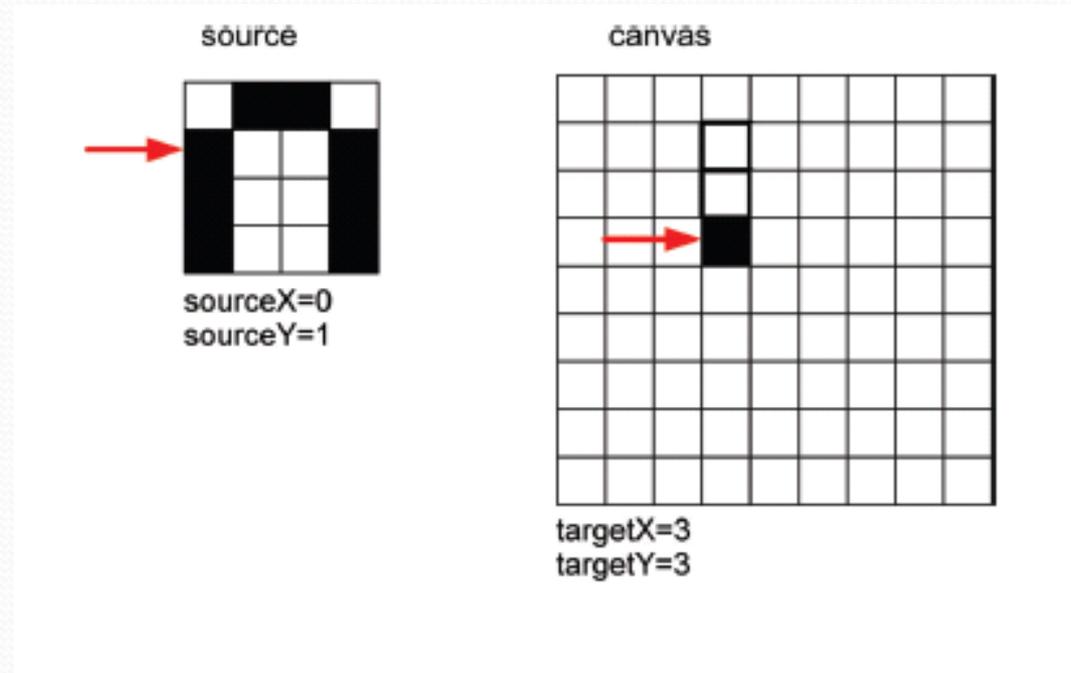
# Scaling up: How it works 2

- But as we increment by *only* 0.5, and we use the `int()` function, we end up taking every pixel *twice*.
- Here, the blank pixel at (0,0) in the source gets copied twice onto the canvas.



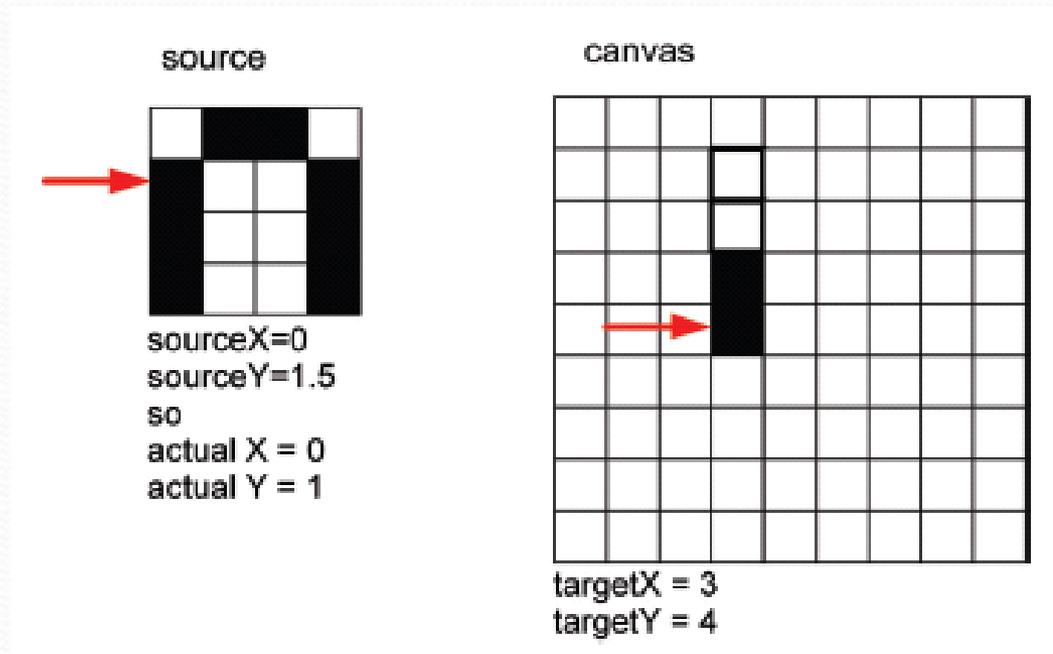
# Scaling up: How it works 3

- Black pixels gets copied once...



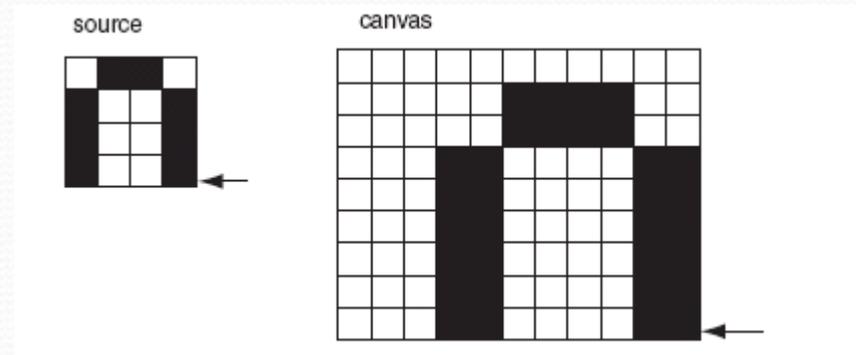
# Scaling up: How it works 4

- And twice...



# Scaling up: How it ends up

- We end up in the same place in the source, but twice as much in the target.
- Notice the degradation:
  - Gaps that weren't there previously
  - Curves would get “choppy”:  
Pixelated



# What to do?

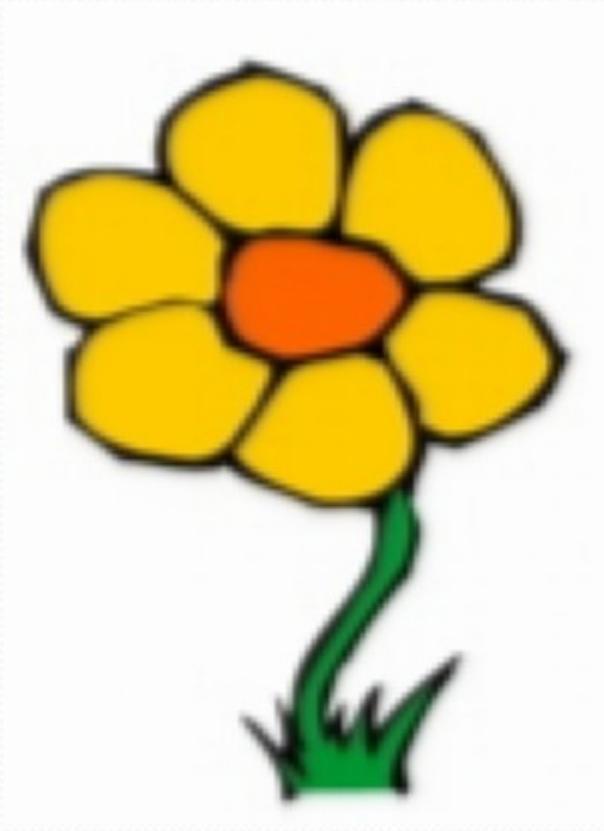
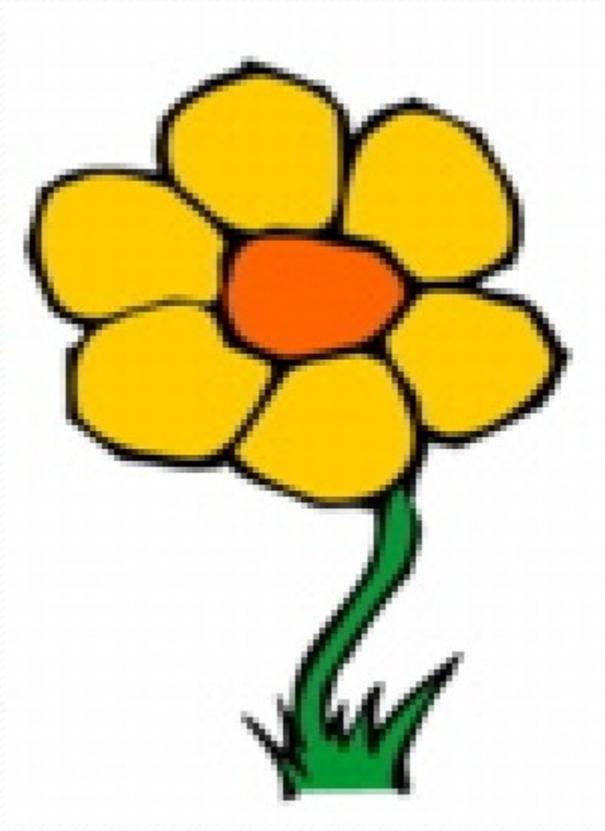
- How do we clear up the degradation of scaling up?
- Variety of techniques, but mostly following the same basic idea:
  - Use the pixels around to figure out what color a new pixel *should* be, then somehow (e.g., by averaging) compute the right color.
  - Different techniques look at different pixels and compute different averages in different ways.

# A blurring recipe

```
def blur(pic,size):
    for pixel in getPixels(pic):
        currentX = getX(pixel)
        currentY = getY(pixel)
        r = 0
        g = 0
        b = 0
        count = 0
        for x in range(currentX - size,currentX + size):
            for y in range(currentY - size, currentY + size):
                if(x<0) or (y<0) or (x >= getWidth(pic)) or (y >=getHeight(pic)):
                    pass # Skip if we go off the edge
                else:
                    r = r + getRed(getPixel(pic,x,y))
                    g = g + getGreen(getPixel(pic,x,y))
                    b = b + getBlue(getPixel(pic,x,y))
                    count = count + 1
        newColor = makeColor(r/count,g/count,b/count)
        setColor(pixel,newColor)
```

**We'll see pass and else later, but you can probably get a sense here of what's going on.**

# Blurring out the pixelation



# Things to try:

- Can you come up with general copy, rotate, copy, and scale functions?
  - Take input pictures and parameters
  - Return the canvas the correct transformation applied
- Also think about generalizing the transformations:
  - Scaling up and down by non-integer amounts
  - Rotating by something other than 90 degree increments