

Activity

Image Representation

Summary

Images are everywhere on computers. Some are obvious, like photos on web pages, but others are more subtle: a font is really a collection of images of characters, and the icons that we use to interact with the operating system on Mac and Windows machines are just images. But how does the computer turn the 0's and 1's stored on its hard drive into colorful images on your screen? Today's lesson hopes to answer just that.

Timeline

What	Time	Where
Introduction	10	ImageRepresentationLessonPlan.docx ImageRepresentationSlides.docx
Hidden Images Worksheet	10	ImageRepresentationWorksheets.docx
Sharing with a Friend	10	ImageRepresentationWorksheets.docx
Compression Activity	10	ImageRepresentationWorksheets.docx
What's It All About	10	ImageRepresentationLessonPlan.docx

Materials

- ✓ Each student will need pencil or pen and the following handouts:
 - Worksheet 1: Hidden Images
 - Worksheet 2: Sharing with a Friend
 - Worksheet 3: Compression Exercise
- ✓ Included PowerPoint slides

Introduction- Whole Class

Lesson Vocabulary (you may want to write on board, maybe as part of the discussion)

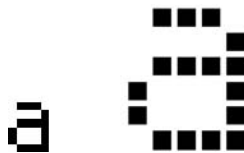
- pixel
- compression

Images are displayed on our computer screen for all sorts of reasons. Videos are just still images shown quickly after one another, you can attach and view images in your email, and browse cat pictures on Google's image search.

Today we'll be exploring how images are represented in a computer. To keep it simple, we'll limit our discussion today to black and white images. A primary focus will be answering the question "How can we store an image using the smallest space possible on our hard drive?"

The Basics.

For starters, use the included PowerPoint slides or draw a 6x5 grid on a whiteboard, coloring in the squares to form an "a" shape. You can tell the students this is what a letter looks like if you were to zoom in really far into the computer monitor. Ask if anyone knows what the small dots on the computer screen are called (these are "picture elements," or "pixels"). When you look at the image from far away, you can see that it is the letter "a."



We will use a fairly simple scheme to turn this image into binary numbers (remember: all of the data a computer ever uses must be stored as binary numbers). Let white pixels be represented by a 0, and black pixels be represented by a 1.

0	1	1	1	0
0	0	0	0	1
0	1	1	1	1
1	0	0	0	1
1	0	0	0	1
0	1	1	1	1

Ask students if they think this is a good idea (answer: it works, but we can do better!). If we stored every pixel of every image, we would run out of room on our computers much faster than we do today. That's because our computers *compress* images to make their file size smaller, but still storing all the data to reconstruct the image. We're going to introduce a new encoding scheme that will use *fewer* numbers to represent the image.

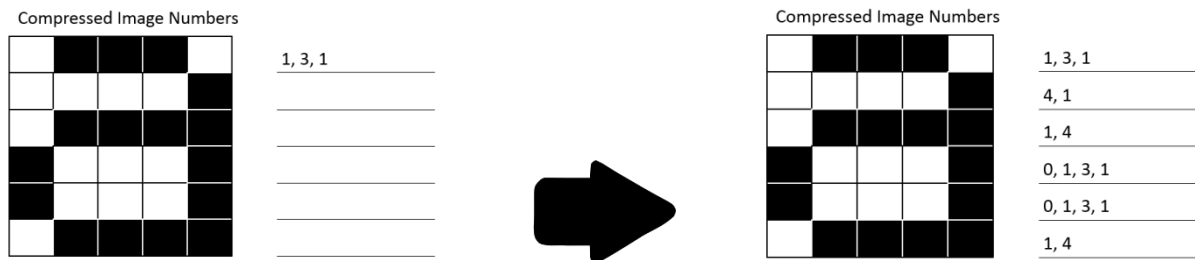
For comparison purposes, ask the students how many numbers would be needed to represent the letter "a" using the simple method above. Answer: we would need $6 \times 5 = 30$ numbers.

Ask the students if they notice any patterns in the image. Point out that there are 3 black pixels together in the first row, four white pixels in the second. Lead the students to the idea that instead of writing down *every* bit, they can describe the pattern. Point out that there is a run of black pixels in the first row, and a run of white pixels in the second. So we need some type of scheme that allows us to know not just how many pixels but what color.

Get the students to agree that we will use these rules:

1. We will clump the colored boxes together if they are adjacent in the image.
2. We will always list the number of *white* pixels in a row *first*. Then alternate between black and white.

The first row of the "a" now becomes 131, because there is 1 white pixel, followed by 3 black pixels, before another white pixel at the end. Display the compressed representation as follows:



How would you encode row 4 (it starts with a black pixel)? Since we need to list the number of white pixels first, we would encode the row as 0131. Why is that? (answer: the computer needs a consistent method to reconstruct the image. If we left out the 0, then the colors in row 4 would be flipped, because the computer would think we were starting off with 1 white pixel, then 3 black pixels, then 1 more white pixel). Emphasize that the sum of the compressed values should equal the total number of pixels in each row. In this example, since each row has 5 pixels, each compressed representation should add to 5.

Worksheets

Worksheet 1: Hidden Pictures

This worksheet has students practice the exact same ideas that we just covered on the whiteboard.

		X			X				
		X			X				
					X				
		X					X		
		X			X				
			X	X					

10
 3, 1, 2, 1, 3
 3, 1, 2, 1, 3
 10
 5, 1, 4
 2, 1, 4, 1, 2
 2, 1, 4, 1, 2
 3, 1, 2, 1, 3
 4, 2, 4
 10

				X	X				
			X	X	X	X			
		X	X	X	X	X	X	X	
	X	X	X	X	X	X	X	X	X
				X	X				
				X	X				
				X	X				
				X	X				
				X	X				
				X	X				
		X	X	X	X	X	X		

4, 2, 4
 3, 4, 3
 2, 6, 2
 1, 8, 1
 0, 10
 4, 2, 4
 4, 2, 4
 4, 2, 4
 4, 2, 4
 4, 2, 4
 4, 2, 4
 2, 6, 2

Worksheet 2: Share with a Friend

Now students will have the opportunity to create their own image, encode it, and pass the encoding to a friend. Students get to practice the *encoding* process. Students know if they encoded correctly because their friend should be able to *decode* the message back into the original image using the bottom half of the worksheet.

Activity - Image Compression

So why do we care about saving space? It's true that compressed images take less space on our hard drive, but hard drives are pretty big these days. But what about movies? Movies and film are actually made up of lots of pictures shown one after another very quickly. Let's say that our movie is made up of 120 images that make up a 'moving picture.'

If it would take 10 seconds for one image to download uncompressed, how many seconds would it take to download the entire **uncompressed** movie? Answer: $120 * 10 = 1200$ seconds. How many minutes is that? Answer: $1200/60$ or 20 minutes.

Clearly this number is not accurate (it does not take 10 seconds/image, and there are more than 120 images in most movies) - but how many students have had to wait for a video to load?

We will wrap up with one last activity.

Worksheet 3: Compression

So far, students have learned how to represent an image using two different methods: the first was to represent every pixel as a 0 or a 1, and the second was to represent groups of pixels, always starting with a group of white pixels. Let's engrain why this is so cool by demonstrating the *transfer* of an uncompressed image (the first method) and a compressed image (the second method).

Overview:

Students will need to split up into groups of two (although it can be done with three). One student will act as a transmitting computer who already has a copy of the image (if doing groups of 3, this will be a single student). The other student will act as a computer who is receiving a copy of the image. Note that worksheet 3 needs to be cut into four parts (described on the worksheet).

The students will go through two rounds of translating the image values into pictures. The key here is that during the first round, the uncompressed version is translated, and during the second round, the compressed version is translated.

Process:

The student acting as the transmitting computer will verbally give the receiving computer values one by one. The receiving computer must notify the transmitting computer that they are ready for data after they have shaded in the correct number of image boxes on the worksheet. It is important to emphasize that in both rounds, students may only give ONE number at a time. For example, the uncompressed receiver may get 1 as their first number and must finish shading one box before asking for another number, while a compressed receiver may get a 3 and can immediately shade three boxes.

Display a timer that all students can see. Students should document their time immediately as they complete their image. Write down the top five times on the board. Do this for both rounds. Students should then be able to see that the compressed image times are much quicker than the uncompressed.

What's It All About Discussion – Whole Class

Computers represent almost everything with some graphical interface. Anything with a screen needs to be able to interpret data and turn it into a displayable image.

Computer scientists care about compression because it allows us to do more on our computers without needing to upgrade any hardware. Imagine this: you can choose the video quality of any video on YouTube. If your internet is slow, you may want to choose a low-quality version so that it will load quicker. We don't like low-quality because it usually looks "blurry" or "pixelated."

Using techniques like we discussed today, we are able to send more information using the same number of steps (think back to the compression exercise: the student receiving the compressed image was able to fill in multiple pixels before needing to ask for more data). When computer scientists create better compression schemes, it's basically a free YouTube upgrade. We can watch better quality videos *without* having to upgrade our internet speed. Yay!

Optional Extension Discussion – Gray Scale

So far we've talked about black and white images. What about gray scale? The slides give a possible scale for gray scale, and show one compression scheme.

Optional Extension Discussion – Pixels per Screen

The number of pixels available is also known as the resolution of the screen. The resolution of the screen to the right is 800x1300. This means that there are 1,040,000 available on the screen

The example to the right shows a sample of what a given image would look like on a screen. What would happen to the image of the dog if the screen resolution was doubled?

The majority of computer screens have a resolution of 1024x768 or higher.



Optional Extension Discussion – Understanding Pixels in Color

The following videos describe how the concepts in this lesson can be extended to describe how the computer deals with color images.

<https://www.youtube.com/watch?v=EXZWHumclx0&t=210s>

<https://www.youtube.com/watch?v=15aqFQQVBWU&t=251s>

Optional Extension Discussion – Audio compression

<http://www.bbc.co.uk/education/guides/zpfdwmn/revision/3>