Today

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Today

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Sounds as arrays

- Samples are just stored one right after the other in the computer’s memory
- That’s called an array
  - It’s an especially efficient (quickly accessed) memory structure
  - each sample is two bytes (or ONE WORD)

<table>
<thead>
<tr>
<th>byte #</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte contents</td>
<td>0</td>
<td>56</td>
<td>1</td>
<td>223</td>
<td>256</td>
<td>2</td>
<td>...</td>
</tr>
<tr>
<td>word contents</td>
<td>56</td>
<td>478</td>
<td>-32766</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
How sound works: Acoustics, the physics of sound

- Sounds are waves of air pressure
  - Sound comes in cycles
  - The frequency of a wave is the number of cycles per second (cps), or Hertz
    - (Complex sounds have more than one frequency in them.)
  - The amplitude is the maximum height of the wave
Figure 2.11 Three sound sources—a tuning fork, a guitar, and a bird—and the sound signals they create.
the sounds more rich and realistic.

Figure 2.12 The guitar signal in Figure 2.11 shown over two different time scales. The plot on the left shows several seconds of the signal, while the plot on the right shows several milliseconds of the signal.
Figure 2.16 Block diagram of the periodic-signal generator.
Figure 2.22 MIDI file producing a sinusoidal signal for the note G4 with a frequency of 392 Hz. The amplitude $A$ and period $T$ of the signal are shown.
Representations of Sound and Images

- Kind of the same idea:
  - number represents the colors at each pixel
  - number represents the fragment of sound wave at very tiny moment in time

- But different, too:
  - blow up a pixel -> looks like a fragment of picture
  - blow up a sample, doesn’t sound like much -- WHY?

  sound is made by changes in value

```python
def changeSampleAt( sound, location):
    sampleLength = getLength( sound)
    setTo = getSampleValueAt( sound, location )
    for num in range( 1, sampleLength ):
        setSampleValueAt(sample, num, setTo )
    return sound
```
But isn’t light made of waves, too?

- Yes, but we don’t represent the parts of a light wave.
  - the color the number makes on the computer screen generates the waves we see
TODAY

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Sine wave

Recipe 70

```python
def sineWave( freq, amplitude ) :
    mySound = getMediaPath("sec1silence.wav")
    buildSin = makeSound(mySound)
    sr = getSamplingRate(buildSin)  # sampling rate
    interval = 1.0 / freq             # interval of sample
    samplesPerCycle = interval * sr   # samples / cycle
    maxCycle = 2 * pi
    for pos in range( 1, getLength(buildSin) + 1 ) :  
        rawSample = sin(( pos / samplesPerCycle) * maxCycle)
        sampleVal = int( amplitude * rawSample )
        setSampleValueAt( buildSin, pos, sampleVal )
    return buildSin
```

![Sine Wave](image)
Square wave

**recipe 72**

```python
def squareWave( freq, amplitude ) :
    mySound = getMediaPath("sec1silence.wav")
    square = makeSound(mySound)
samplingRate = getSamplingRate(square)  # sampling rate
seconds = 1
interval = 1.0 * seconds / freq        # interval of sample
samplesPerCycle = interval * samplingRate  # samples / cycle
samplesPerHalfCycle = int(samplesPerCycle / 2)
sampleVal = amplitude
i = 1
for s in range( 1, getLength( square ) + 1 ) :
    if (i > samplesPerHalfCycle):
        sampleVal = sampleVal * -1
    i = 0
    setSampleValueAt( square,s, sampleVal )
i = i + 1
return square
```
def triangleWave( freq ) :
    amplitude = 6000
    samplingRate = 22050  # sampling rate
    seconds = 1
    triangle = makeEmptySound( seconds )  # create a sound object (the book uses “sec1silence.wav”)
    interval = 1.0 * seconds / freq  # interval of sample
    samplesPerCycle = interval * samplingRate  # samples / cycle
    samplesPerHalfCycle = int(samplesPerCycle / 2)
    increment = int( amplitude / samplesPerHalfCycle )
    sampleVal = -amplitude
    i = 1
    for s in range( 1, samplingRate + 1 ) :
        if (i > samplesPerHalfCycle):
            increment = increment * -1
            i = 0
        sampleVal = sampleVal + increment
        setSampleValueAt( triangle, s, sampleVal )
        i = i + 1
    return triangle  # return the sound (the book says play)
Today

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Shifting the frequency

Figure 2.22 MIDI file producing a sinusoidal signal for the note G4 with a frequency of 392 Hz. The amplitude $A$ and period $T$ of the signal are shown.

Notice that higher frequencies take less time and lower frequencies take more time. Changing the frequency of a sound changes its duration and vice-versa.
Shifting the frequency

- recipe 68, modified
- how sampling keyboards work....
- A lot like scaling pictures, isn’t it?

```python
def shift( soundFile, factor ) :
    source = makeSound( soundFile )
    target = makeSound( soundFile )
    sourceIndex = 1
    sourceLength = getLength( source )
    for targetIndex in range( 1, sourceLength + 1 ) :
        setValueAt( target, targetIndex, getValueAt( source, int( sourceIndex )))
        sourceIndex = sourceIndex + factor
        if sourceIndex > sourceLength :
            sourceIndex = 1
    return target
```
Today

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Adding sounds - like combining pictures!

- recipe 71 (part 2)

```python
def addSounds(sound1, sound2):
    for index in range(1, getLength(sound1) + 1):
        s1Sample = getSampleValueAt(sound1, index)
        s2Sample = getSampleValueAt(sound2, index)
        setSampleValueAt(sound2, index, s1Sample + s2Sample)
    return sound2
```

What would happen if we added two normalized sounds?
How would you change this to add different length sounds?
Echo, echo, echo, echo

recipe 64

def echoes( soundFile, delay, num ):
    s1 = makeSound( soundFile )
    ends1 = getLength( s1 )
    ends2 = ends1 + (delay - num)
    s2 = makeEmptySound(1 + int( ends2 / getSamplingRate(s1) ) )
    echoAmplitude = 1.0
    for echoCount in range( 1, num + 1 ) :
        echoAmplitude = echoAmplitude * 0.6  # each echo is 60% of previous
        for posn1 in range( 1, ends1 ) :
            posn2 = posn1 + (delay* echoCount )
            values1 = getSampleValueAt( s1, posn1) * echoAmplitude
            values2 = getSampleValueAt( s2, posn2)
            setSampleValueAt( s2, posn2, values1 + values2 )
    return s2
• Representation
  • sound and image representations
• Sine, Square, and Triangular waves
• Pitch-shifting / compressing
• Combining (adding) sounds
• Group Project 2: sound abstractions
• Assignment 5
Group Project 2: sound abstractions

- What should you do?
- Need to have everyone contribute a sound
- What rules should we create?
- Consider our experience with the visual abstractions.
- We’ll decide next week.
- Only difference is that Friday (10/17) lab is to write specification & start writing code
- DUE Friday (10/24) 2:00 PM
Group Project 2: sound abstractions - EXTRA CREDIT

- Maybe we should have some ideas about abstract sound

- Extra credit Wednesday (10/15)
  - Short report on abstract sound (5 minute max including demo)
  - Presentation to class
  - Electronic music? Contemporary music? Sound artists?
  - Worth same as EC for visual abstraction - one question on Final


Group Project 2: sound abstractions - NEW GROUPS

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Currin</td>
<td>Burke</td>
<td>Bowers</td>
<td>Davies</td>
<td>Ho</td>
<td>Dahyia</td>
<td>Burton</td>
</tr>
<tr>
<td>2</td>
<td>Demase</td>
<td>D'Augustine</td>
<td>Duffy</td>
<td>Heitzer</td>
<td>Howell</td>
<td>Ha</td>
<td>Highman</td>
</tr>
<tr>
<td>3</td>
<td>Malhotra</td>
<td>Maier</td>
<td>Hughes</td>
<td>Taylor</td>
<td>Merrow</td>
<td>Nassery</td>
<td>Rhyner</td>
</tr>
<tr>
<td>4</td>
<td>Regione</td>
<td>Talley</td>
<td>Knowles</td>
<td>Walsh</td>
<td>Slack</td>
<td>Pham</td>
<td>Thayer</td>
</tr>
<tr>
<td>5</td>
<td>Zhang</td>
<td>Tran</td>
<td>Messick</td>
<td></td>
<td></td>
<td>Roithmayr</td>
<td></td>
</tr>
</tbody>
</table>
Today

- Representation
  - sound and image representations
- Sine, Square, and Triangular waves
- Pitch-shifting / compressing
- Combining (adding) sounds
- Group Project 2: sound abstractions
- Assignment 5
Assignment 5

- Faster and Faster (or Higher and Higher)
- For a sound:
  - increasingly compress the sound:
    - 0% - 25%  1:1 (no compression)
    - 25%-50%  1:1.25
    - 50% - 75%  1:1.5
    - 75% -100% 1:2 (twice as fast)
  - print out how much shorter in seconds the compressed sound is
  - save the sound to a file
Assignment 5

- For extra credit on Final Exam
- For a sound:
  - `#comment that you are doing the challenge`
  - `increasingly compress the sound:`
    - 0% - 25%  1:1 (no compression)
    - 25% -100% smoothly change from 1:1 to 1:2 (twice as fast) instead of in steps
  - `print out how much shorter in seconds the compressed sound is`
    - this method should produce different results from basic
  - `save the sound to a file`
Questions?

- So what have we looked at today that could help with this HW?
- How?
COMING ATTRACTIONS

- Monday:
  - read chapters 7 & 8
  - quiz (on Chapter 8, only) due at 10:00 AM

- Next Wednesday:
  - HW Project 5 due 10:00 am

- Next Friday:
  - come to class with Group Project 2 ideas