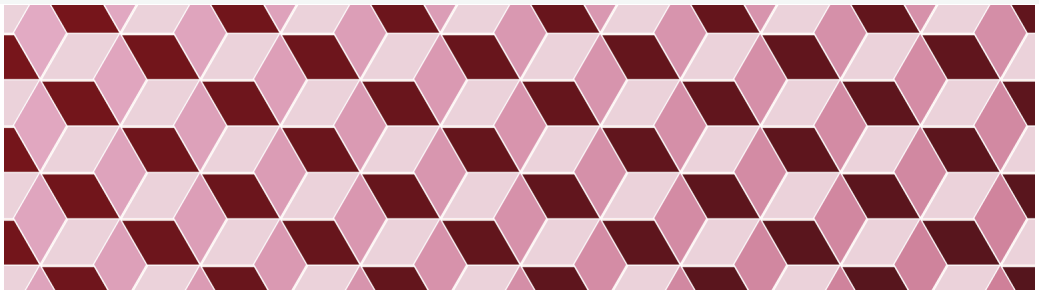

15-104 Introduction to Computing for Creative Practice

Fall 2021

15 Randomness

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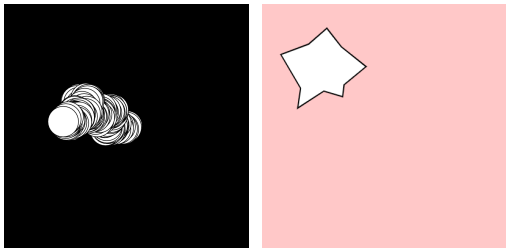
1

Brownian Motion

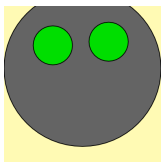
- We have seen several examples of randomness based on calling the `random` function.
- Either we use the number directly, or we use the numbers as offsets to create what is often called a "drunken walk" or **Brownian motion**.



2

Wandering Eyes (Brownian Motion)

```
var leftX = 60;
var rightX = 140;
var leftY = 50;
var rightY = 50;
var noiseParam = 0
var noiseStep = 0.1;

function setup() {
    createCanvas(200, 200);
    frameRate(10);
}

function eye(x, y) {
    fill(0, 222, 0);
    ellipse(x, y, 50, 50);
}
```

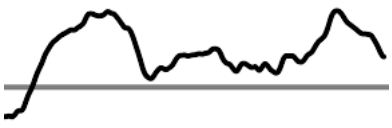


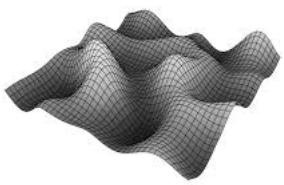
```
function draw() {
    background(255, 250, 180);
    fill(100);
    ellipse(100, 80, 200, 200);
    eye(leftX, leftY);
    eye(rightX, rightY);
    leftX += random(-2, 2);
    leftY += random(-2, 2);
    rightX += random(-2, 2);
    rightY += random(-2, 2);
    noiseParam += noiseStep;

};
```

3

Perlin Noise (p5.js reference)

- The `noise` function returns a smoothly varying value as a function of 1, 2, or 3 parameters that can be interpreted as time, space, or both. Perlin noise is a random sequence generator producing a more naturally ordered, harmonic succession of numbers compared to the standard **random()** function.
- The resulting value will always be between 0.0 and 1.0.





4

Perlin Noise (p5.js reference)

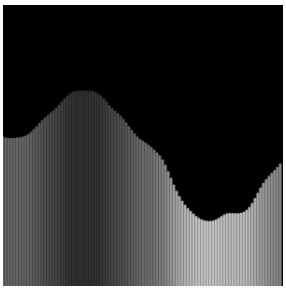
```
var xoff = 0.0;

function setup() {
    createCanvas(200, 200);
}

function draw() {
    background(204);
    xoff = xoff + 0.01;
    var n = noise(xoff) * width;
    line(n, 0, n, height);
}
```

What do you think happens if you increment the x-offset (`xoff`) by 0.1 instead of 0.01?

5

Perlin Noise (p5.js reference)

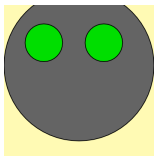
```
var noiseScale=0.02;

function setup() {
    createCanvas(300, 300);
}

function draw() {
    background(0);
    for (var x=0; x < width; x++) {
        var noiseVal = noise((mouseX+x)*noiseScale,
                             mouseY*noiseScale);
        stroke(noiseVal*255);
        line(x, mouseY+noiseVal*80, x, height);
    }
}
```



6

Perlin Noise

```
var leftX = 60;
var rightX = 140;
var leftY = 50;
var rightY = 50;
var noiseParam = 0;
var noiseStep = 0.1;

function eye(x, y) {
    fill(0, 222, 0);
    var offset = noise(noiseParam);
    offset = map(offset,0,1,-20,20);
    ellipse(x + offset, y, 50, 50);
|}
```



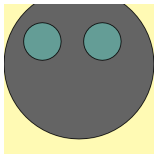
```
function setup() {
    createCanvas(200,200);
    frameRate(10);
}


function draw() {
    background(255,250,180);
    fill(100);
    ellipse(100, 80, 200, 200);
    eye(leftX, leftY);
    eye(rightX, rightY);
    noiseParam += noiseStep;
};
```

Perlin noise is a deterministic function: You put in the same parameters and you get out the same value.

7

Perlin Noise

```
var leftX = 60;
var rightX = 140;
var leftY = 50;
var rightY = 50;
var noiseParam = 0;
var noiseStep = 0.1;

function eye(x, y) {
    var offset = noise(noiseParam);
    offset = map(offset,0,1,-20,20);
    fill(0, 222, 0);
    fill(100,
      noise(noiseParam*0.2+100)*255,
      noise(noiseParam*0.2+100)*255);
    ellipse(x + offset, y, 50, 50);
}
```



```
function setup() {
    createCanvas(200, 200);
    frameRate(10);
}
function draw() {
    background(255, 250, 180);
    fill(100);
    ellipse(100, 80, 200, 200);
    eye(leftX, leftY);
    eye(rightX, rightY);
    noiseParam += noiseStep;
};
```

Perlin noise for the eye color.

8

Uniform vs. Gaussian Noise

- **Uniform** noise spreads values equally across a fixed range.
  - *Example:* `random(15,104)` returns a random number in the range [15, 104) with equal probability.* *pseudo-random number generator
- **Gaussian** noise implements a normal distribution, where generated values tend toward a certain average value (called the *mean*), with more or less random variation around the mean determined by the *standard deviation.*
  - *Example:* `randomGaussian()` returns a random number so that over time, the mean is 0 and the standard deviation is 1.
  - Example: `randomGaussian(15)` returns a random number so that, over time, the mean is 15 and the standard deviation is 1.
  - Example: `randomGaussian(104, 15)` returns a random number so that, over time, the mean is 104 and the standard deviation is 15.

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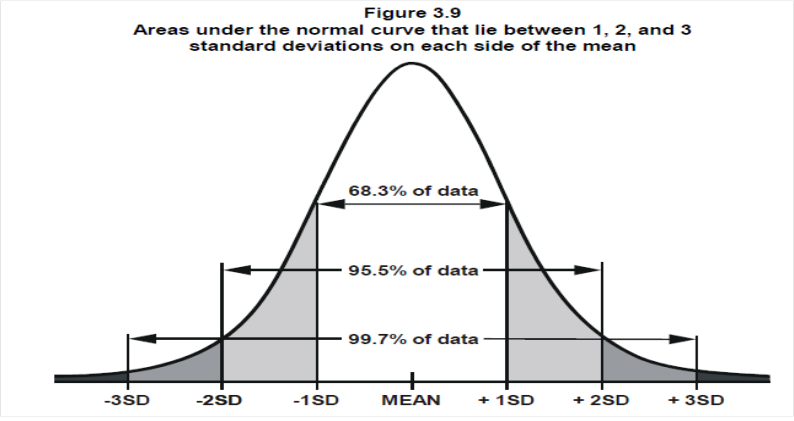
Normal Distribution



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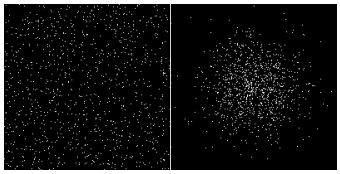
Uniform vs. Gaussian Noise

```
function setup() {
    createCanvas(
       400,200);
    background(0);
}
```



```
function draw() {
    stroke(255);
    line(width/2, 0, width/2, height); // draw center line
    fill(255); // points are white
    for (var i = 0; i < 1000; i++) {
        // Uniform on the left, Gaussian on the right
        push();
        translate(100,100);
        point(random(-100,100), random(-100, 100));
        pop();
        push();
        translate(300,100);
        point(randomGaussian(0, 30), randomGaussian(0, 30));
        pop();
    }
    noLoop();
}
```

There are probably some Gaussian points that are outside the bounds of the right square. Why?

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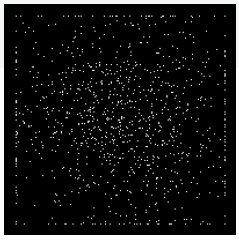
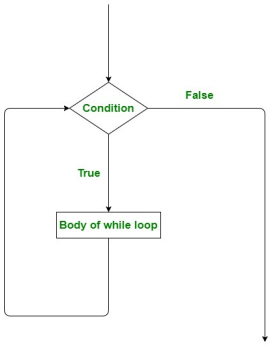
Gaussian with Limits



- If the value generated is off the canvas, you could just set it to some default value (e.g. 10 units away from the border), but you will get a distinct border.
- Better solution: keep generating random numbers until you get something in bounds.
- We can use a while loop to do this:

```
while (condition) {
    loop body
}
```

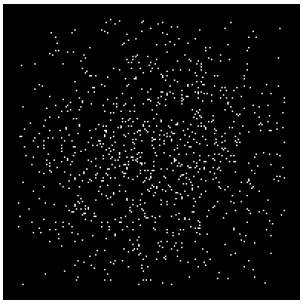


geeksforgeeks.org

12

Uniform vs. Gaussian Noise

```
push();
translate(width/2, height/2);
for (var i = 0; i < 1000; i++) {
    // Gaussian noise for both x,y centered on canvas
    var x = randomGaussian(0, 50);
    while (x < -width/2 + 10 || x > width/2 - 10) {
        x = randomGaussian(0, 50);
    }
    // x must be on the canvas now
    var y = randomGaussian(0, 50);
    while (y < -height/2 + 10 || y > height/2 - 10) {
        y = randomGaussian(0, 50);
    }
    // y must be on the canvas now
    point(x, y);
}
pop();
```



The complete `draw` function is not shown.

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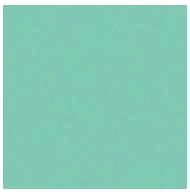
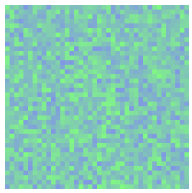
Gaussian for Colors

```
function setup() {
    createCanvas(200,200); frameRate(1);
}

function draw() {
    var range = 50;
    background(0); noStroke();
    for (var x = 0; x < width; x += 5) {
        for (var y = 0; y < height; y += 5) {
            var r = randomGaussian(0, mouseX / 5);
            while (r < -range || r > range) {
                r = randomGaussian(0, 0, mouseX / 5);
            }
            fill(128, 200 + r, 180 - r); // add some random to G & B
            rect(x, y, 5, 5);
        }
    }
}
```



`mouseX` near 0



`mouseX` near `width`

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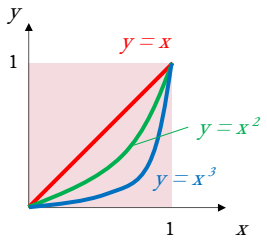
Try This: Exponentiation

You can use exponentiation to scale an effect so that most of the time the effect is small, but once in a while it is large. The higher the power, the more pronounced the effect is. In p5.js, `Math.pow(a,b)` returns a^b.

```
var skew;

function setup() {
    createCanvas(200,200); frameRate(10);
}

function draw() {
    background(0);
    skew = map(mouseX, 0, width, 1, 10);
    fill(Math.pow(random(1), skew) * 255);
    ellipse(width/2, height/2, width/2, height/2);
}
```



How does the program behavior change as you move the mouse left and right?

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