Introduction to Computer Graphics
198:428
Lecture – March 11, 2019
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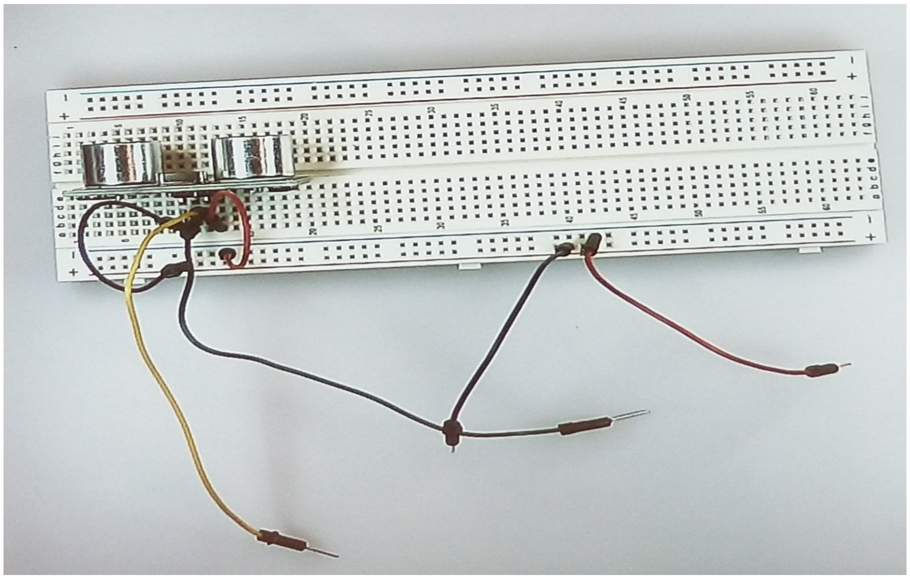
- Topic 1: Announcements
  - HW 2 is posted on class website
    - Problem 1:
      - the humanoid model can be uploaded or can be built by the student—please note somewhere in your assignment if you build the model yourself to receive necessary credit for doing so
      - no wrist joints necessary, just those noted on the assignment description
    - Problem 2:
      - the next topic will help significantly with this question
    - HW Reminders:
      - carefully read submission instructions at the top of the assignment. All necessary documents should be zipped into one file
      - be mindful of time—none of the questions can be implemented quickly

- Topic 2: Building circuit for ultrasonic sensor
  - Pins and connections
    - connect 1 pin to 5V
    - connect 1 pin to GND
    - connect echo pin to pin 10 on arduino
      - the echo pin is responsible for sending and receiving the signal
    - connect trigger pin to pin 9 on arduino
      - the trigger pin is responsible for measuring the time between the sending/receiving of the signal



  - Ultrasonic sensor lobes
    - lobe 1 sends ultrasonic pulse
    - lobe 2 receives ultrasonic pulse

- → Testing the circuit
  - Sketch: ultra_v1 (with comments)

```
const int trigPin=9;
const int echoPin=10;

long duration;
long distance;

void setup(){
	pinMode(trigPin, OUTPUT);
	pinMode(echoPin, INPUT);
	Serial.begin(9600);
}
void loop(){
	digitalWrite(trigPin, LOW);
	delayMicroseconds(2);

	//begin measurements
	digitalWrite(trigPin, HIGH);
	delayMicroseconds(10);
	digitalWrite(trigPin, LOW);

	//longer time means further away, shorter means closer
	duration=pulseIn(echoPin, HIGH);

	//this is the conversion from time to distance
	distance=duration*.034/2;

	Serial.print("Distance: ");
	Serial.println(distance);
}
```

  - can physically test the sensor by placing your hand in front of the sensor and watching the distance change as you move your hand closer and further away from the sensor

- ➢ Topic 3: Ordinary Differential Equations

$$\dot{U} = du/dt = u\,(v-2)$$

$$\dot{V} = dv/dt = v\,(1-u)$$

- → u, v
  - functions of time
  - cannot solve these systems independently
  - INPUT: u(0), v(0)
  - OUTPUT: u(t), v(t)
  - Somewhere in a 2-D plane lies u(0), v(0) and the goal is to find the trajectory moving forward

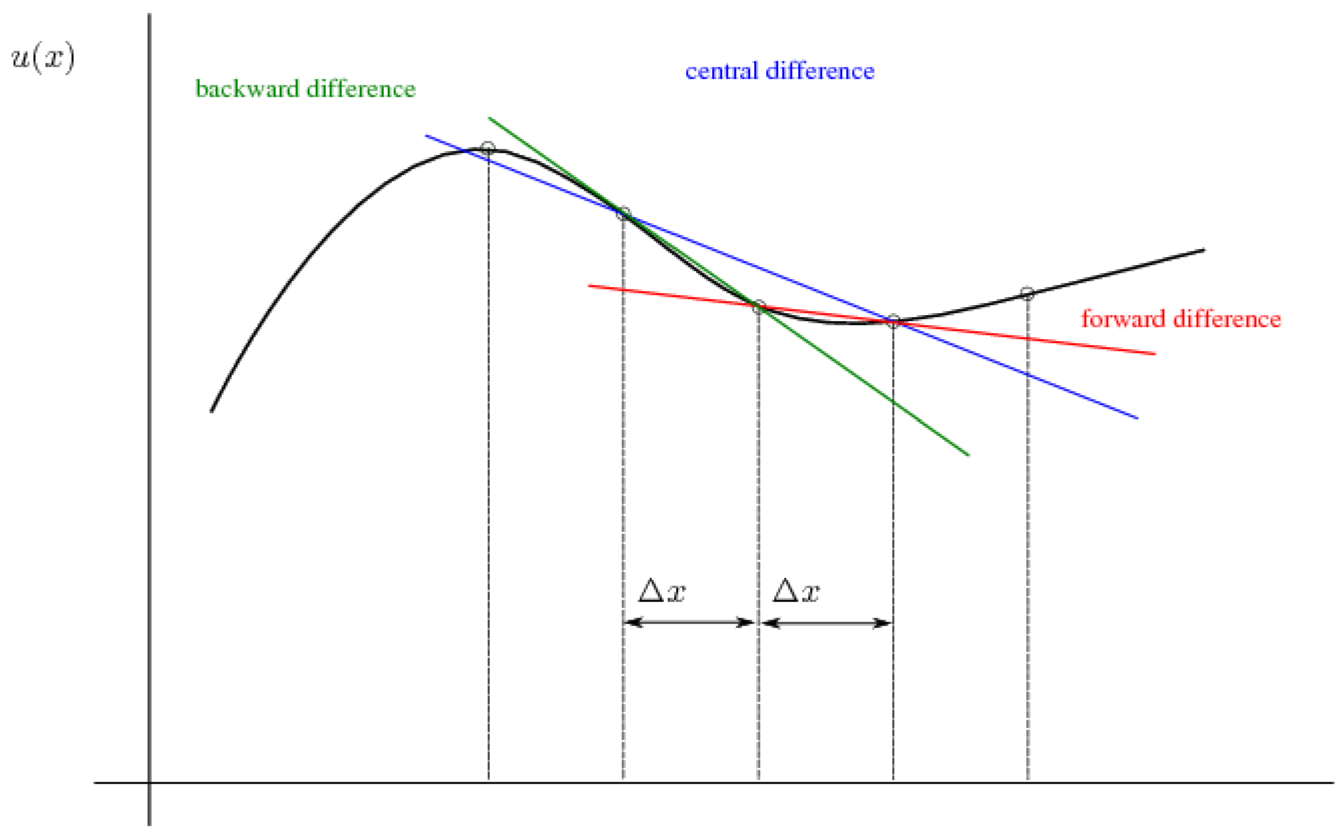
- The equations comprise a model called the Lotka-Voltera Model
  - created for the predator/prey problem—as one population increases the other decreases and over time this will switch and become a cycle

→ Discretize time – steps of Δt

$u^0 = u(0)$	$v^0 = v(0)$
$u^1 = u(\Delta t)$	$v^1 = v(\Delta t)$
$u^2 = u(2\Delta t)$	$v^2 = v(2\Delta t)$
…	…
$u^n = u(n\Delta t)$	$v^n = v(n\Delta t)$

→ 3 approaches:

forward differencing:	$(u^n - u^{n-1}) / \Delta t$	1st order accuracy
backward differencing:	$(u^{n+1} - u^n) / \Delta t$	1st order accuracy
central differencing:	$(u^{n+1} - u^{n-1}) / 2\Delta t$	2nd order accuracy



→ Foward differencing

- Advantage: builds on previous quantities
- Draw back: how far away you move in time is limited

$$(u^{n+1} - u^n) / \Delta t = u^n(v^n - 2)$$
$$(v^{n+1} - v^n) / \Delta t = v^n(1 - u^n)$$

so,

$u^{n+1} = u^n + \Delta t[u^n(v^n - 2)]$
$v^{n+1} = v^n + \Delta t[v^n(1 - u^n)]$

- see python code posted by professor for way of computing this electronically
  - play around with the code by decreasing time and increasing number of steps and observe the result
  - students are encouraged to write their own code for the following methods

→ Backward differencing

- Advantage: gives flexibility to take longer steps—numerical damping
- Draw back: requires solving a quadratic equation—more expensive than explicit form

$(u^{n+1} - u^n) / \Delta t = u^{n+1}(v^{n+1} - 2)$ … (Eq. 1)
$(v^{n+1} - v^n) / \Delta t = v^{n+1}(1 - u^{n+1})$ … (Eq. 2)

$u^{n+1} = u^n / [1 - \Delta t(v^{n+1} - 2)]$ … (Eq. 3)

substitute 3 in 2:

$(v^{n+1} - v^n) / \Delta t = v^{n+1} \{1 - (u^n / [1 - \Delta t(v^{n+1} - 2)])\}$

$= v^{n+1} \{[1 - \Delta t(v^{n+1} - 2) - u^n]/[1 - \Delta t(v^{n+1} - 2)]\}$

$v^{n+1} - v^n\{1 - \Delta t(v^{n+1} - 2)\} = \Delta t\, v^{n+1}\{ 1 - \Delta t(v^{n+1} - 2) - u^n\}$

→ Symplectic differencing

- Advantage: Energy conserving

$(u^{n+1} - u^n) / \Delta t = u^n(v^{n+1} - 2)$
$(v^{n+1} - v^n) / \Delta t = v^{n+1}(1 - u^n)$

alternatively,

$(u^{n+1} - u^n) / \Delta t = u^{n+1}(v^n - 2)$
$(v^{n+1} - v^n) / \Delta t = v^n(1 - u^{n+1})$