CS 134

Video Game Math

Game Engine Architecture
Chapter 4

Today in Video Games

Twin Galaxies Adjudication Issues Statement In Regard To Billy Mitchell Donkey Kong Dispute

by Twin Galaxies Editorial Staff, February 2, 2018 4:55 PM

More add codes

Homework questions?

Video Game Math

While the game is running, guys are moving around.

Where are they at any point in time?

When you click, which tile got clicked on?

Video Game Math

- Algebra, Linear Alegbra , Geometry, and Trigonometry are the common maths of Video Games.

  - And a smidge of basic Calculus... just a smidge!

- Let's do a review of the math needed when writing games.

Video Game Math

Video Game Math

- Algebra and Geometry
  - Algebra — Solve for X: $X^2 + 6 = 10$
  - Geometry — Properties of Circles, Triangles

- Pythagorian Theorem

- Quadratic Formula

- Simple motion

Video Game Math

- How long would it take to move from Start to End?
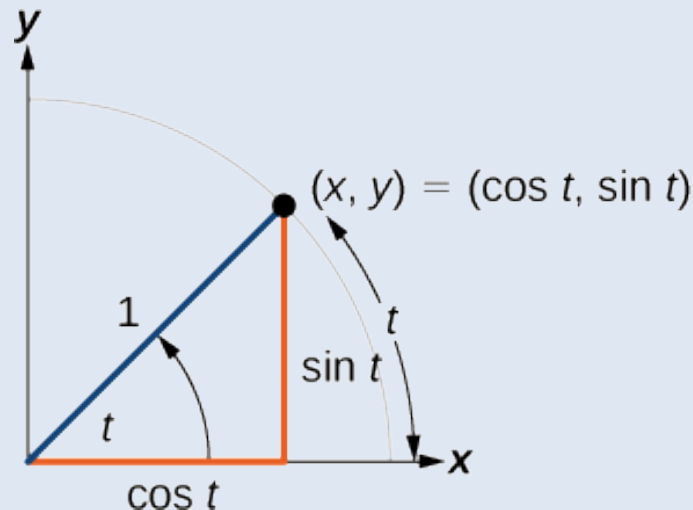
- Assume speed of 30px / second.

Video Game Math

- How long would it take to move from Start to End?

- Assume speed of 30px / second.

- Needed info:
  - Delta X = 4 tiles
  - Delta Y = 2 tiles
  - 1 tile = 16x16 pixels

Video Game Math

- Trigonometry
    - Sin, Cos, Tan as the circle functions
- $\cos^2(x) + \sin^2(x) = 1$
- atan2, one of the most useful functions.

Video Game Math

- What angle should the character be rotated to face the direction they are walking?

- Remember:

  - Delta X = 4 tiles
  - Delta Y = 2 tiles
  - 1 tile = 16x16 pixels

Video Game Math

- Viewing these operations as doing Linear Algebra makes a lot of the operations easier.

- Linear Algebra according to MathWorld is:
  - The study of linear systems of equations and their transformation properties.

- This is **NOT** the way game developers view Linear Algebra.

Video Game Math

- Viewing these operations as doing Linear Algebra makes a lot of the operations easier.

- Linear Algebra according to game devs is:
  - The study of 2D and 3D positions and how they change in different views.

Video Game Math

- Video Game Linear Algebra:
  - Instead of viewing the world as having X values and Y values, view the world as a collection of (X,Y) values.
    - This is a POINT or a VECTOR.
  - A transformation to another view of the world is represented as a collection of new values for the X, and Y axes.
    - This is a MATRIX.
- Linear Algebra is the math you can do on POINTS, VECTORS, and MATRICES.

Video Game Math

- Many linear algebra operations have geometric meaning:

  - Magnitude (length)

  - Weighted average (a.k.a. barycentric coords)

  - Dot product (Angle between vectors)

- To calculate magnitude, use the Pythagorean theorem

  - Length(24,32)   = sqrt(24 * 24 + 32 * 32)

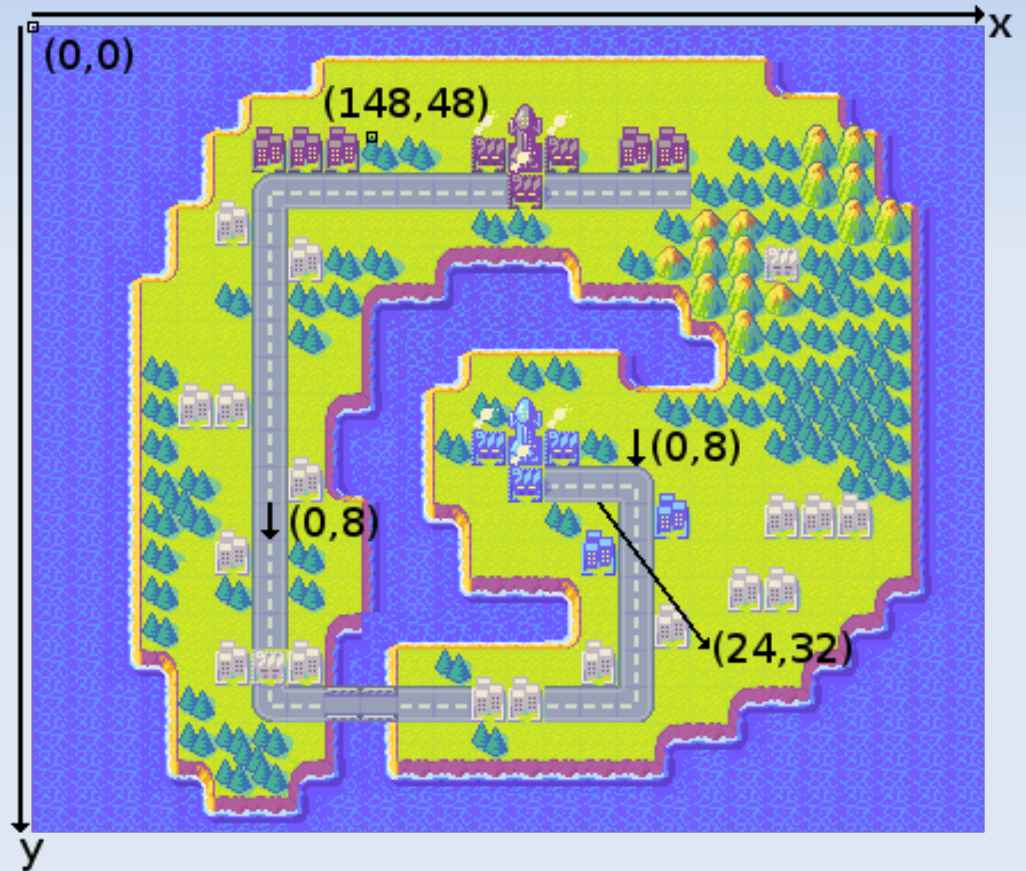   = sqrt(1600)

                     = 40

Video Game Math

- To do a weighted average, do a bunch of scalar multiplies and adds that sum up to one

  - 0.2 * (24, 32) + 0.8 * (0, 8)

    = (4.8, 6.4) + (0, 6.4)

  - = (4.8, 12.8)

- To calculate dot product, multiply the X and Y parts together and add the result.

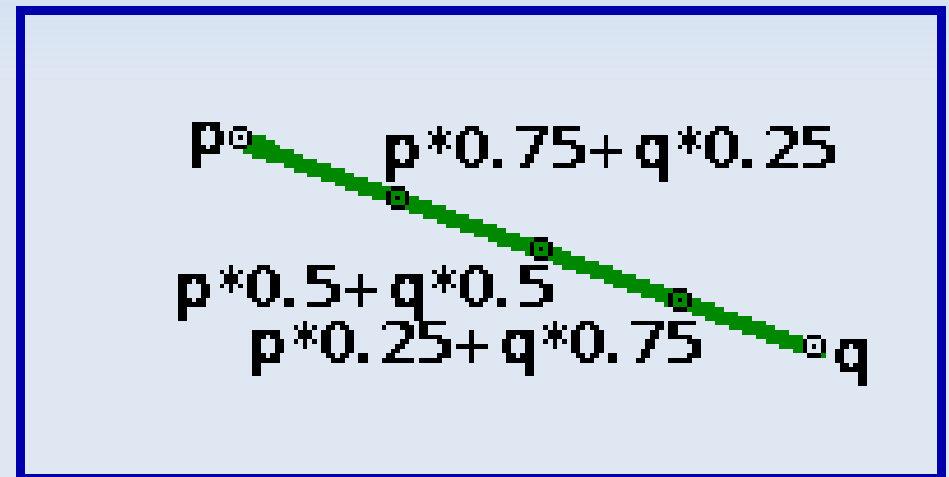 - Dot((24,32), (0,8))   = 24 * 0 + 32 * 8

    = 256

Video Game Math

- Origin is upper left
- Points
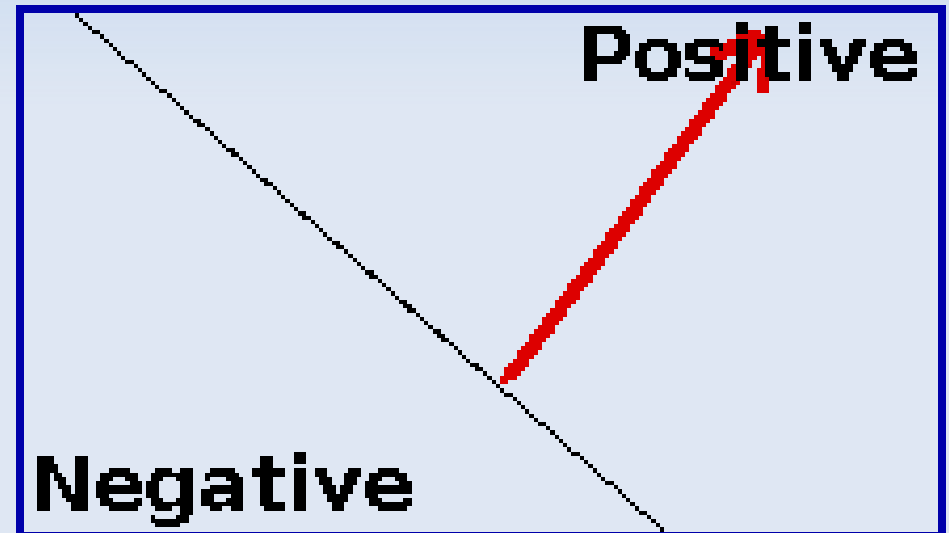 - Position in world
- Vector
  - Change in position

Video Game Math

- Weighted Average

  - Has geometric meaning as long as weights add up to 1

- Animating this is called Linear Interpolation or "lerp"

p $\bullet$

p*0.75+ q*0.25

p*0.5+ q*0.5

p*0.25+ q*0.75

$\bullet$ q

Video Game Math

- The dot product

- v · w = Length(v)
                * Length(w)
                * cos θ

- If you look as the sign, you can see if two vectors are pointing in the same direction.

Video Game Math

- Let's solve some real game problems:

  - Choose "direction" for animation to play.

  - Determine visiblity in a stealth game.

  - Animate characters moving.

Video Game Math

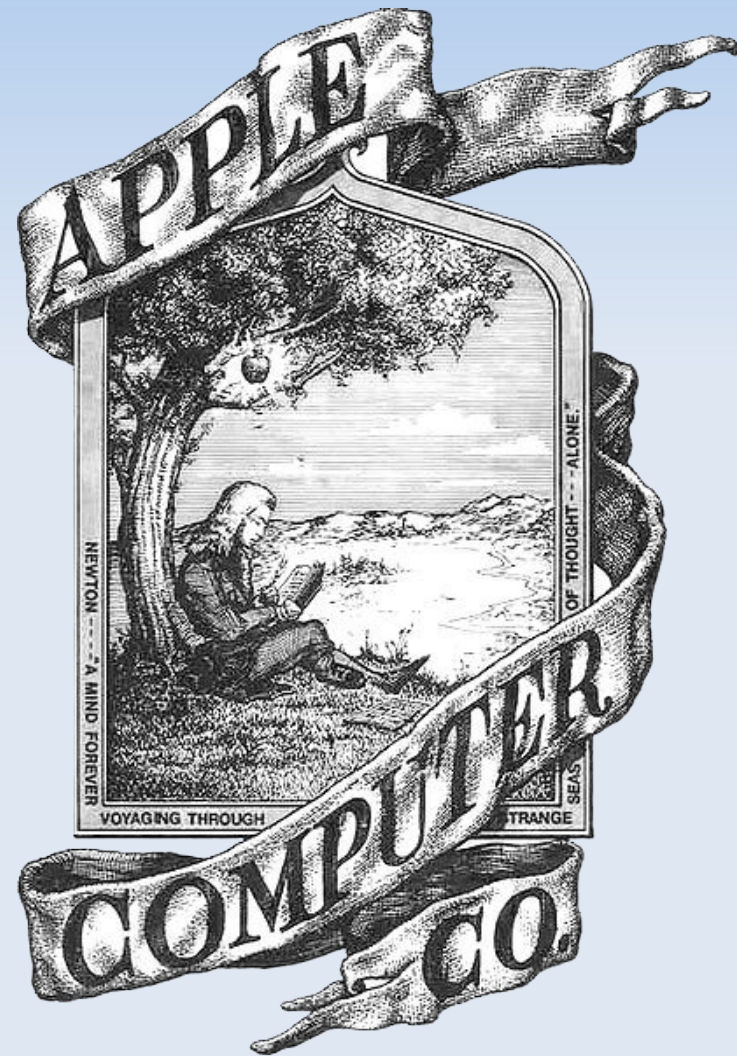# Video Game Math

Video Game Math

Video Game Math

- What about Matrices and 3D?

- Matrices are generally not needed for 2D. They are extremely useful in 3D.

- Other useful 3D only things:
  - Cross product (perpendicular)
  - Determinant (volume)
  - "Left Hand" vs "Right Hand" coordinate systems

Video Game Math

- And what about Calculus?
  - We will cover calculus when we get to video game physics.

Video Game Math

- The math you will use is:
  - Algebra and Geometry
  - Trigonometry
  - Linear Algebra

- One nice thing about Linear Algebra is everything you will do has geometric interpretations.

Video Game Math

Questions?

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