Computer Programming

“Software Development”
- Process of creating programs

Use programming languages
- Java
- C++

Goal
- Program accomplishes task
Programming Languages

- **Language** human and computer can understand
- **Tell the computer what calculations to do**
- **Algorithm**: a set of instructions that solve a problem
Software Development

Idea 🕯️
def primeFactors(num):
    i, l = 2, []
    while i <= math.sqrt(num):
        while num % i == 0:
            num = num // i
            l.append(i)
        i += 1 if i % 2 == 0 else 2
    return l + ([] if num == 1 else [num])
Software Development

Idea

Programmer writes

Code

Run by computer

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Computer Simulations

- Simulations are models
  - Realistic
  - Predictable (consistent)
- Objects represent physical things
- Interactions between objects
  - Gravity
  - Collisions
Simulation Specifics

Objects move around by translocation

Each object has a vector
  - Magnitude
  - Velocity

Compare objects for interactions
  - Done in pairs
Real-time

- Time to compute not noticeable
- Appears smooth
  - No stuttering
- Instant reaction to user interaction
  - No “lag”
Real-time Modeling

- Must run fast
- Discrete velocities

A Frame

Simulation Calculations

Display to Screen
Collision Modeling

Detection
- Has a collision occurred?
- When did it occur?

Response
- What is each object’s new velocity?

Collision Algorithm
Collision Detection

Collision occurs when:
- Objects intersect
- Objects touch

Time of collision is when objects first touch
- Where paths intersect
Collision Detection

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Collision Response

- Conservation of Momentum
  \[ \sum m v_i = \sum m v_f \]

- Resultant velocity depends on impact angle

- Energy may be lost
  \[ v = C_R v_f \]

- Inelastic collision
Single Collision Algorithm

- Common method
- Not realistic
My Project

- Increase accuracy by addressing problems
  - More realistic
- Minimize extra computation time
My Approach

- Assume collisions are independent
- Repeat collision algorithm for successive collisions
- After first collision:
  - Avoid repeating calculations
  - Only test distance left to travel

\[ x_f = x_i \cdot (1 - \text{timepassed}) \]
New Result

More realistic

Multiple collision checks

Frame 1 → Collision Algorithm → Frame 2
**Experiment**

**Initial State:**
- 150 circles in a 30×50 grid
- Random velocities

**Experiment:**
- Run for 600 frames
- Measure time elapsed
- Vary number of collisions

Single Collision Algorithm

Multiple (2) Collision Algorithm
Single Collision

240 frames
Multiple (2) Collisions

240 frames
Computation Time per Frame vs. Frequency of Collisions

![Graph showing the relationship between computation time per frame and frequency of collisions. The graph plots average time (milliseconds) against radius (pixels) for single and multiple (2) collisions.]
Conclusion

50% speed decrease
- Better than running original algorithm twice
- Speed decrease depends on frequency of collisions

Greater accuracy
- Objects do not “stick” to each other
- Objects more evenly distributed
- More realistic
Applications

- Physical Simulations
- Virtual Reality
- Video Games
- Computer-Assisted Design (CAD)
- Animation

BallHead