Computational Intelligence
Particle Systems

Unit # 08

What is common in all these objects?

Fuzzy Objects

Particle System

- A particle system is a collection of many minute particles that together represent a fuzzy object.
- Over a period of time, particles are generated into a system, move and change from within the system, and die from the system.”

—William Reeves, "Particle Systems—A Technique for Modeling a Class of Fuzzy Objects," ACM Transactions on Graphics 2:2 (April 1983), 92.

A Particle

- A particle usually has following attributes:
  - Position
  - Velocity
  - Lifetime or Age
  - Color
  - Shape
  - Size
  - Transparency

Particle Lifespan

- Each particle undergoes following phases:
  - Generation
  - Movement
  - Rendering
  - Extinction

Particle Generation

- Particles are generated by means of a controlled stochastic process such as:

$$N = m_p + r\sigma_p$$

Where N is number of particles generated in a given frame m_p and σ_p are the mean and variance of number of particles. r is a random number.

- Similar process can be used to initialize the speed and color of particles.

Particle Dynamics

- Each particle has a position vector X and is moved by adding a velocity vector to it.

$$X_{(t+1)} = X_t + V$$

- Acceleration factor alters the speed of the particle and allows to simulate gravity and other external forces.

$$V_{(t+1)} = V_t + A$$

Extinction

- Each particle is given a lifetime.
- Life of a particle is decremented in each frame.
- A particle dies when its life becomes 0.
- There can be other killing mechanism too like hitting on ground.

Parameters in action

https://www.youtube.com/watch?v=heW3vn1hP2E

Genesis Effect

- https://cal.cs.umbc.edu/Courses/CS6967-F08/Papers/Reeves-1983-PSA.pdf
- Making of the Genesis Sequence from Star Trek II – YouTube
- "Genesis effect" for Star Trek II - The Wrath of Khan - YouTube

Simulation

- Effects:
- https://www.khanacademy.org/partner-content/pixar/effects/particle/v/fx4-final

- Fluid Particles: Real-time particle-based 3D fluid simulation
- https://www.youtube.com/watch?v=DhNt_A3k4B4

Visualization of Swarms (by CI students)

- Blossoming Spring - Particle Systems

  by Fizza Rubab, Ruhama Naeem, Spring 2024

- Boiling Water and energy conservation

  by Muneeb Shafique and Sajeel Alam, Spring, 2024

- Ant Colony Optimization - Simulation

  by Osama Yousuf, Spring 2019

References

- https://natureofcode.com/book/chapter-4-particle-systems/
- https://www.khanacademy.org/partner-content/pixar/effects/particle/v/fx4-final