Pollinating Flowers with Particle Swarm Optimization

A Blender animation by Lakelon Bailey

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Project Goal

- Create an animation where bees come out of a hive, fly around and pollinate flowers, and then return to the hive.

- Implement Particle Swarm Optimization (PSO) to help bees find flowers

Bee Behavior

Basic Movement

- Add the product of the velocity unit vector and speed to position each frame

- Constant speed of 1m/frame

- Bees bounce off invisible boundaries

- Rotate to face the direction they're going

- Maximum turning radius of 30°

Particle Swarm Optimization (PSO)

- Solve a solution using particles that communicate with one another -> Bees
- Track a personal best and global best
- Update velocity on each frame
- Equation:

$$P_{vel} = w.P_{vel} + R_1.C_1.(P_{best} - P_{pos}) + R_2.C_2.(S_{best} - P_{pos})$$

$$P_{pos} = P_{pos} + P_{vel}$$

Pollination

- Bees use PSO to find and pollinate flowers
- Bees "attach" to flowers
- Only 5 bees can be "attached"
- Bees ignore flowers that are at max capacity
- Bees iterate the flower's pollination counter until it reaches the pollination threshold (fully pollinated)
  - Pollination threshold = (frame rate * min pollination time) * max nearby bees = (24fps * 12s) * 5 = 1,440 pollinations
  - 1,440 pollinations required for the flower to become fully pollinated.
- Takes a minimum of 12 seconds to pollinate a flower.

Behavior Stages

- Three stages
  - Leaving hive (Stage 1) – Bees leave the hive on a constant trajectory and don't look for flowers yet.
  - Swarming (Stage 2) – Bees look for and pollinate flowers.
  - 3. Returning to hive (Stage 3) – Bees return to the hive and stop when they get there.

Python Scripting

Scripts Used

- generate-bees-and-flowers.py
- clear-bees-and-flowers.py
- generate-keyframes.py

Generate Bees and Flowers Script

- generate-bees-and-flowers.py
- Builds off the default Bee and Flower.
- Generates 50 more flowers and 200 more bees
- Creates a new material for each Pod child of the Flower to allow color changes on specific pods for pollination
- Makes sure flowers are evenly spaced

Generate Keyframes Script

- generate-keyframes.py
- Clears existing animation data
- Calculates bee movement/behavior on every frame
- Sets Flower Pods to correct color on every frame
- Handles Bee behavior transitions

Clear Bees and Flowers Script

- clear-bees-and-flowers.py
- Removes all animation data for all objects
- Removes duplicated Bees and Flowers
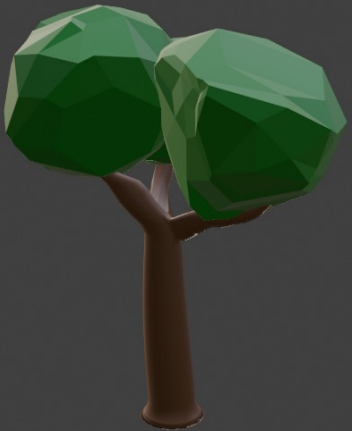
Animation

Primary Objects

Bee

Pollinated Flower

Tree

Unpollinated Flower

Hive

Animation Process

- Added grass floor
- Created Bee and Flower models
- Created and duplicated Tree and spread evenly throughout scene
  - Left a large space open for the flower patch
- Created the Hive and attached it to the Tree overhanging the flower patch
- Ran scripts
- Added camera movement to keyframes