AE6102 Project Proposal

Game of Flies

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Abstract

The world around us is composed of inherently simple building blocks that come together in large numbers to create complex and fascinating emergent behaviours. It is also possible to demonstrate such emergent behaviour for other simple rules applied to a large number of agents. In this project, we intend to create real-time interactive simulations with a large number of simple particles. We expect to see a large number of interesting patterns and behaviours, including flocking (akin to swallows), complex 'lifeforms' and more.

1 Outline

The main goal of the project is to simulate the actions of a group of particles by utilizing predetermined rulesets : Force Profiles. The simulation process will begin with initializing arrays of particle positions and velocities alongwith cosmetic parameters like radius, colours, headings etc, and then updating these arrays according to the Force Profile of the selected system. The final step being the **real-time** visualization of the outcomes using suitable means, suplemented alongside with interactive UI elements for the user. The simulation code is likely to be divided into two parts, one doing the calculation and publishing the data, and the other taking that data and visualizing it.

The backend involves the generation of the next configuration of the particle system given an initial configuration, a Force Profile, and a time step. Inclusion of different Force Profiles creates different opportunites to optimize them individually using optimization libraries to handle a large number of particles/agents. The visualization of the findings will be initiated using *matplotlib* (for rudimentary visualization during development) and then advanced to *Mayavi* for real-time 2D/3D visualization. An interface will be created to combine the processing and visualization modules using either *tkinter*, *TraitsUI*, or *PyQt5* (whichever suits our needs), with the addition of interactive elements for user. We haven't decided yet, which libraries to use for the code optimization or visualization (one of numba or compyle). If time permits, the project submission will also include an Ideal Gas simulation, running multiple instances of a system simultaneously (ensemble for statistical evaluation) with *automan*.

2 Deliverables

We expect to produce an interface that has a window to visualize the particle system (2D and 3D) and its motion in real-time, while also providing UI elements to dynamically control the parameters associated with the system. These include the number of particles, particle types, Force Profiles (and their parameters), Interaction with the particles like Drag and Drop Brush etc.
Some key points we wish to complete are as follows:

- Optimisation for maximum number of particles through Parallelisation.
- Different Force Profiles :

  - Clusters (for 2D) [2]: A system which is less computationally intensive and therefore a suitable candidate for a real-time simulation.
  - Boids (for 3D) [1]
  - Ideal/Real Gas Ensemble Simulations:
    A set of virtual copies of a system initialized randomly which lends itself to automation using *automan*.

- Visualization : Interactive, Real-Time, Dynamic Camera

Extra Goals:

- Inter-particle Collision Detection and Response for Macroscale Simulations

Outcomes:

- Demonstration of complex, emergent behaviour in a particle system given a basic set of rules.

3 Timeline

Assuming 4 bi-weeks and any extra time as buffer period, the tentative timeline is listed below:

- **Weeks 1 & 2** :
  A naive implementation of a 2D and 3D particle system following 'Clusters' and/or 'Boids' and a rudimentary visualization (matplotlib)
- **Weeks 3 & 4** :
  Benchmarking optimizations and switching to a better Visualisation Platform.
- **Weeks 5 & 6** :
  Start work on the UI and integrating controls with the system parameters, also embedding the visualisation into the UI.
- **Weeks 7 & 8** :
  Buffer Period and time to work towards Inter-Particle Collision implementation and/or another particle-system.

4 Git Repository

Link to the public GitHub Repository of this project:
https://github.com/vinitdoke/Game_of_Flies

References

[1] Craig W. Reynolds. "Flocks, herds and schools: A distributed behavioral model". In: *ACM SIGGRAPH Computer Graphics* 21.4 (Aug. 1987), pp. 25–34. DOI: 10.1145/37402.37406. URL: https://doi.org/10.1145/37402.37406.

[2] Jeffery Ventrella. *Clusters*. URL: https://www.ventrella.com/Clusters/.