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# Emergence in Gaming Systems

Emergence is not a new subject or topic when it comes to games; in fact, Emergent Behavior exists in most modern video games, with few exceptions. The theory behind it was actually coined in early classical times with philosophers such as Pluto, Socrates and Aristotle[1]. The idea is that Emergence occurs when similar entities follow a set of rules, of which involving interaction with one another. What results is that the behavior of the observed system is more complex and sophisticated than the individual elements of and the rules they follow. In a real world setting, snowflakes are a good example. By itself, water particles aren't interesting and quite simple, they fall to the ground. When they are near other water particles in lower temperatures with wind influences, the system where the particles freeze, join together, rotate, then repeat cause snowflake patterns to emerge, that anyone initially observing the rules of the system would not have been able to predict. Ants work similarly as by themselves they don't do anything and work off instinct. With thousands together they gather food for the whole colony, protect the queen and build complex tunnels[2].

Emergence can be classified into two main categories: emergence that is predictable (weak emergence) and emergence that is unpredictable (strong emergence)[3]. Weak emergence is most prevalent in video games, for example queuing in racing games, as behavior that emerges from the interaction between the game rules, the environment, and the entities within it. This produces new behavioral patterns that, while following the rules, are capable of being predicted as to how it came to be. Strong emergence is when there are the same entities in an environment interacting with one another, but of which the cause of their behavior cannot be initially predicted by the observation of rules. An example of this is Conway's Game of Life. Conway's Game of Life followed simple rules, but the interaction of the creation, death and stable state of the cells created patterns such as 'gliders', a collection of entities that after a few cycles, returns to its initial state but one cell down and to the right. This simulates movement of a single object. Further elaboration created a 'glider gun', an oscillating entity that spawns gliders repeatedly[4]. This behavior could not have been predicted when looking at the initial rules of Conway's Game of Life, thereby fulfilling the idea of Strong Emergence.

My project Boids used simple entities, the titular 'Boids' which are representations of flocking creatures like birds or fish, and simple rules of cohesion, alignment and separation. I further attempted to improve on this after the initial project, attempting to create 'attraction points'(in the real world this is represented as food) to influence flocking behaviors. However through study of the topic I realized unless I had initially created the system to allow feed based cohesion, where instead I used an average mass of the birds as their central point of cohesion, the entire system itself would have to be rewritten to allow that sort of emergent behavior[5]. Hence, the pitfalls of the topic started to emerge as well. Weak Emergence is a critical point in any AI/A-life design, how stimuli continuously affect the entities and how they interact to form what could simulate the connections in systems collected thought pattern, and has difficulties altering later on unless it is planned and predicted for implementation from the start.

When I tried to create real-time attraction points, it was based on the mouse click generating a point that would in turn override all of the Boid's 'avgPosOfOthers', a value that was calculate to be the average position of all the other birds, and in turn force them all to flock to that one spot. However due to the rate of which the computer constantly recalculated the positions of all the other Boids, whenever I tried to interrupt or move the point, of which didn't work to attract the Boids in the first place, it caused frequent crashing. I now know that the best course of action/design I should have taken was instead of calculating all the Boids at once as a vector container within the .cpp of it, I should have had each Boid act completely based around all the other Boids around it individually. Therefore, instead of averagePosOfOthers being calculated as a group for each Boid, each single Boid calculating for every other position of every other Boid in the map, it should have been focused on Boids immediately surrounding that one Boid. This would allow one Boid to calculate the Boids in a small distance around it, easing up computation power and allowing more natural flocking patterns to emerge instead of the bee swarm like pattern that emerged at higher numbers.

In conclusion, emergence is common in near all games and systems in modern society. It is prevalent in nature, philosophy, neurology, and computer systems. It is a critical part in creating natural and lifelike AI movements and thought patterns; taken to a higher level it allows an AI to learn and pass on its information and knowledge through computerized biochemistry. Anyone seeking to become an excellent developer and designer of AI and game systems won't be able to do so without a powerful backing in Emergence.

# Bibliography

[1]. Aristotle, [*Metaphysics*](http://en.wikipedia.org/wiki/Metaphysics_%28Aristotle%29), Book H 1045a 8-10: "... the totality is not, as it were, a mere heap, but the whole is something besides the parts ...", i.e., the whole is greater than the sum of the parts.

[2]. Guy W. Lechy-Thompson, AI and Artificial Life in Video Games, p148.

[3]. Guy W. Lechy-Thompson, AI and Artificial Life in Video Games, p152.

[4]. http://upload.wikimedia.org/wikipedia/commons/e/e5/Gospers\_glider\_gun.gif

[5]. Guy W. Lechy-Thompson, AI and Artificial Life in Video Games, p152: "Intelligence is not an extra. If the game is designed in such a way that AI/A-Life could be added as an improvement "later on" the effort needed would negate any benefits that it might bring."

# References

1. Guy W. Lechy-Thompson, AI and Artificial Life in Video Games.  
2. Boids (Flocks, Herds and Schools, a Distributed Behavioral Model http://www.red3d.com/cwr/boids/  
3. Boids http://kaytdek.trevorshp.com/projects/computer/neuralNetworks/boids.htm  
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5. 3D Boids Simulations http://www.navgen.com/3d\_boids/  
6. Wikipedia: Swarm Intelligence http://en.wikipedia.org/wiki/Swarm\_intelligence