COLLABORATION AND COMPETITION IN BOIDS SIMULATIONS WITH PREDATION

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Abstract. This *work-in-progress* paper presents our ideas about collaboration and competition mechanisms in boid simulations. There is an analogy between boids and entities of complex system simulations, and we try to use collaboration and competition mechanisms observed in boid simulations to improve load-balancing of entities in distribution of complex system simulations.

Keywords. complex system, boids, swarm intelligence, collaboration, competition

1 Introduction

Boids were introduced by Craig Reynolds in [1] to simulate collective animal behavior like birds flocks or a particles system.

This is done by defining three rules named "*collision avoidance*", "*velocity matching*" and "*flock centering*" that each boid must respect. The first one avoids that a boid collides with other nearby boids, while the second try to match velocity of a boid with ones of its neighborhood and the last try to keep a boid near of its neighborhood. Figure 1 describes these three rules.

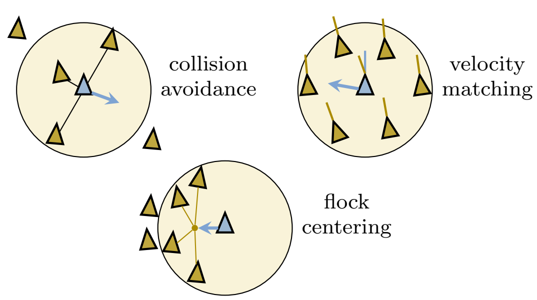

Figure 1: *Boid rules as defined by* C. Reynolds, *considering the blue boid. Circle defines neighborhood of the boid.*

1.1 Extended Model

This model can be extended by creating species of boids. This leads to consider only boids of the same species that the target boid when applying the three rules above and to introduce a new rule "*others attraction*" which allows to define between a boid of the α species and a boid of the β species an attraction factor $\Gamma_{\alpha\rightarrow\beta}(d)$, where d is the distance between the two considered boids. If this factor is negative, then α-boids will be pushed by β-boids while if the factor is positive, α-boids will be attracted by β-boids. The attraction factor $\Gamma_{\alpha\rightarrow\alpha}(d)$ can be used to model the rule "*collision avoidance*" and "*flock centering*": if d is less than a defined value δ_α, then the attraction factor become negative to avoid the collision, else the attraction factor is a Gaussian function which allows a boid to stay in a group but to not be attract by this group if distance is too high.

The "*others attraction*" rule allows to create a prey-predator model using boids behavior. From this point of view, the three first rules above can be seen as a collaboration mechanism allowing boids of a same species to survive, while the attraction or repulsion between two different species can be seen as a competition mechanism: boids on the bottom of the food chain try to escape to the top of the food chain while the top try to caught the bottom. In both cases, the survey of the species depends on the ability to escape/catch other boids.

1.2 Self Organizations

When two boids are close enough to be attracted or pushed, there is an *interaction* between these boids. According to the attraction factor, there are groups of boids with a large amount of interactions between group members. These groups are called organizations and since their creation emerges from the individual behavior of boids, groups are qualified of self-organizations.

Competition between boids, ie. repulsion between two species, and collaboration, ie. attraction between two boids, allow this self-organization. Without competition a single group is created, and without collaboration no group is created.

2 States of boid organizations

A first part of this work is to show the existence of states depending to the attraction factor between boids of a same species. This is an analogy with basic states of matter (ie. gas, liquid, solid) which can be seen in terms of molecular interactions. In literature, we can find some work using such physical analogy, like [2] which uses cohesion between particles to realize a dynamic and decentralized load-balancing.

If the attraction factor between boids is less than a threshold ρ_1, then there is not any cohesion and boids move regardless of other boids like particles of a *gas*, filling as much as possible their environment. If the attraction factor is more than ρ_1 but less than ρ_2, there are cohesion between boids leading to several groups of boids evolving into the environment: boids enter in a *liquid* state. When attraction factor is more than ρ_2, cohesion between boids becomes too high, groups become compact and stop to evolve like particles of a solid matter. The existence of thresholds ρ_1 and ρ_2 is assumed, a first part of this work is to find how to characterize these thresholds. These three states in boids organizations are shown in figure 2.

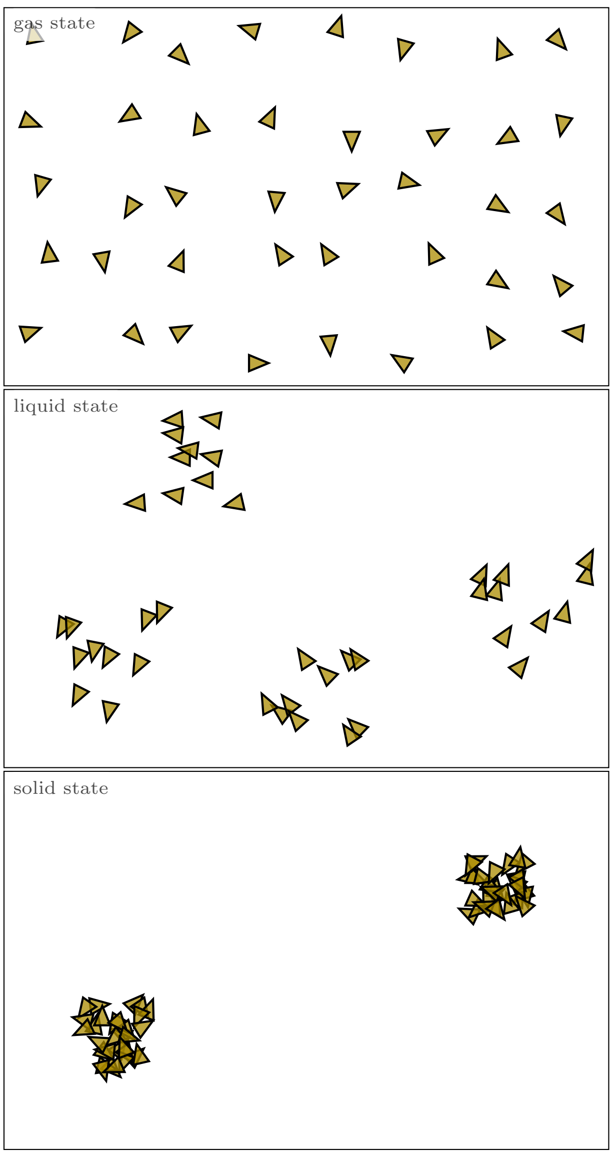

Figure 2: *Gas, liquid and solid states of boids.*

After showing the existence of these three states (gas, liquid, solid), the next part of this work is to show that boid species demography could be characterized according to the species state. We assume that cohesion, which depends on the attraction factor, in a group of boids may help members of this group to avoid predators. If cohesion is too low and consequently group is in a gas state, then there is no real cohesion between members and boids are left to themselves. If cohesion is too high (group is in a solid state), then each boid will focus on stay nearest of its group rather than escape to predators. When a group is in a liquid state, collaboration between members is optimal: attraction between members is low enough to avoid a compact group easily catch by predators, but it is sufficient for the behavior of a member impact on its neighbors. Moreover, informations handle by each boid is optimally reflected in the whole organization.

3 Application

Interest for group states is described in the following. In [3], we are interested on the distribution of complex system simulations composed of a massive set of generic actors called entities. Two entities can communicate, and we call this communication *interaction*. From these interactions emerge organizations, which are groups of strongly connected entities. According to interactions, entities are distributed dynamically on available machines.

We assume that the behavior of an entity is similar to the one of a boid. In both cases there are interactions between actors and emergence of organizations. Interactions impact on entity/boid behavior, leading for boid to modify its direction and for entity to modify (or not) its location (ie. machine on which entity is running).

Predators of an entity α are entity β located on the same machine but such that there is no interaction between α and β. β is a predator for α if number of β organization members locate of the machine is larger than the number of α organization members locate on the machine. As organization of an entity evolves, hierarchy between entities may change dynamically.

4 Conclusion

In this paper, we present our ideas about the existence of states of boids groups, assuming that the state of a group impact on its ability to resist to predators. We would try to study these states to apply them to entities in complex system simulations, improving load-balancing of entities in distribution of such simulations.

Actually, we can observe these states, and we have to discover a way to characterize state changes. Then we have to find how to adapt attraction factor between boids to provide a better resistance to predators of boids organizations. The final part is to translate this study to entities load-balancing in complex system simulations.

References

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