**Summary and Outlook**

One of the advantages of the model used in this paper is its simplicity. There are only few parameters to choose and the swarming is modelled by only using friction and central forces. The anti-Newtonian force keeps the system in movement despite loss of energy due to friction. The computation is also not that complex and therefore does not cost a lot of computation time per step which can be done in a reasonable amount of time. Our model uses the Euler method to solve the differential equations. This could be replaced by a more accurate method like Runge Kutta but we considered Euler as precise enough. However, too much agents added to the simulation will slow down the computation. On the other hand too much agents make it hard to explore the behaviour of individuals.

The swarming simulation of the model can reproduce the basic behaviour of a swarm when the right parameters are chosen. Some of the simulations approximate the behaviour of swarming observed in nature like a fish swarm attacked by a predator, although the simulations in the paper are not in the three dimensional Cartesian plane. To do the computations in the 3 dimensional plane could possibly improve the behaviour of the swarm.

The interaction of the preys as a group but also as an autonomous individual is also a remarkable result of this model. When the swarm of preys gets split into several parts, all those little swarms try to stay together and eventually connect to another swarm. This can be interpreted as an optimal behaviour of a swarm since it also occurs in nature.

When a prey gets scatted away from the swarm it acts autonomous and tries to go back to the swarm. It is possible to interpret this behaviour as a predator catch a prey directly.

Clearly the model is too simple to capture the exact behaviour of swarming observed in nature. To adjust this problem it would help to add more parameters to the model. For example a prey could consider a predator at a certain distance not as a danger or simply add a range of influence to every agent. Randomness or noise which certainly occurs in nature could also be added to the model to allow agents making error in their behaviour. The angle of vision or the direction of the wind is also a parameter which is important in nature, so the predator can sneak up undetected to the swarm from a certain direction.

Another disadvantage is that the predators do not have a specific hunt tactic as for example lions do have in nature. The model distinguishes between three forces between the predator which approximates such behaviour but does not follow an explicit strategy. To adjust such a behaviour more involved and organism specific computations have to be done. In such a case it would be necessary to first study the behaviour of a certain species from a biological point of view and then develop a specific model.

In spite of everything the model used in this paper gives a good approximation of basic swarming behaviour. The described simulations and result do reflect roughly the natural behaviour of swarming.

It is hard to analyse what behaviour of preys and what kind of shape is the best for preys attacked by a predator. Certainly the found configurations are close to the optimum since the behaviour described by the simulation is approximately the one observed in nature. If it would not be optimal then in course of time the behaviour would have been wiped out. Predator prey behaviour is a interplay between both parties.

Accurate swarming models can be used in a lot of technical applications. For example for controlling unmanned vehicles for military purposes or controlling robots within the body for killing viruses or cancer. Certainly the models need to be adapted to a certain application but the model described in this paper gives a flavour of how this can be achieved.