Univerza v Ljubljani
Fakulteta za računalništvo
in informatiko

Collective detection based on visual information in animal groups

Ana Macedo
Patricia Alcázar Andrés
Vulnet Alija

05. January
2022

Collective detection based on visual information in animal groups

To avoid predator threats and better locate resources, animals use the strategy of forming a **group**, because as the "many eyes" hypothesis states, as the size of the group increases, there are progressively more eyes scanning the environment [1].

Collective detection based on visual information in animal groups

But how does the structure of the group influence their **collective visual detection**? And how does the position of an individual inside a group affect its **individual visual detection**?

Problem Definition

Some species of fish adapt to using **visual stimuli** for survival. Analyzing the connection of the **visual feedback** from each fish is important for making future realistic predictions.

The probability that the group will respond to environment reactions is largely **dependent** on the **available visual perception** at any given moment.

The problem that needs to be addressed is having a correct description of the **dependency** of the **group vision** in schooling fish on the **individual fishes' position** in the school. The approach to solve this issue is by analyzing the vision that each golden shiner fish has in the group.

Collective detection based on visual information in animal groups

Jacob D. Davidson et al. investigated how is individual and collective visual detection of gold shiner fish dependant on various parameters, ie. the number of individuals in a group, the state of the group (swarming, milling, polarization etc.), the position of the individual within the group etc.

Collective detection based on visual information in animal groups

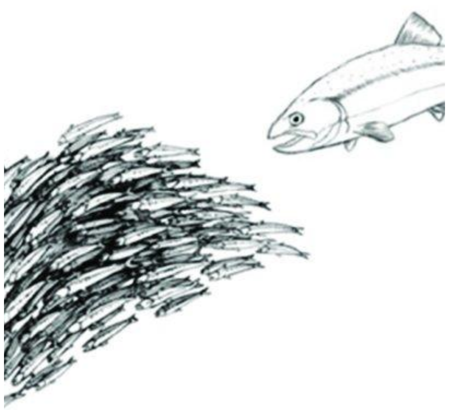
Result

A model which estimates the visual capabilities of a given group depending on two main parameters which is **the probability of visual blockage by a neighbour** and **the density of the group**.

Starting goal

Our project goal was to study this paper, replicate their results, and analyse them with different sizes of groups.

Since Jacob D. Davidson et al. concluded that **state** (swarming, milling, polarization etc.) of the group **does not** have an **effect** on individual or collective detection, we have decided to add a **predator** to the context to observe how **individual** and **collective visual information** change according to predator **attack**.



Methods

We focused on two main aspects: individual detection coverage and collective detection capability, where detection coverage is the fraction of the external visual field that an individual can see.

We have decided to conduct trials with four groups, each having different number of agents (40, 80, 110 and 181), and compare that with the results that the team in has produced in the original paper.

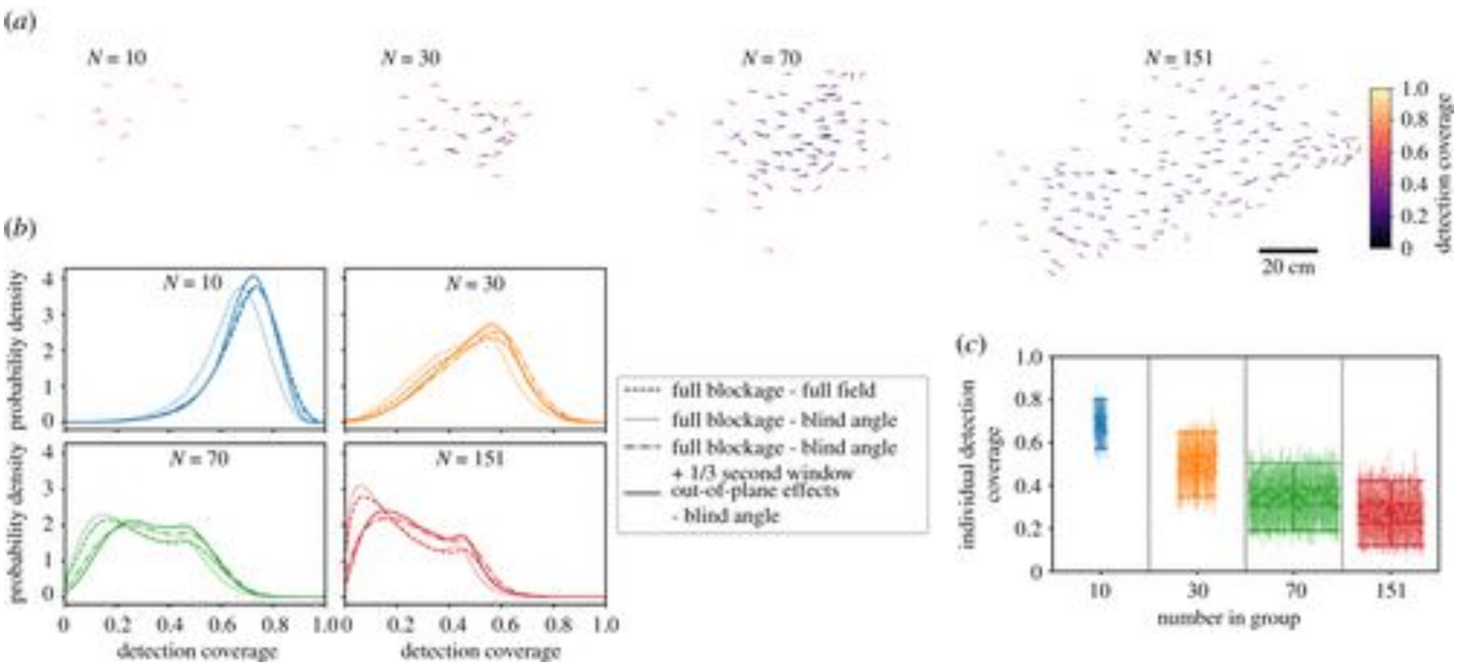
Methods

To analyse the predator attack effect on the group we implemented a simple predator avoidance algorithm [4], adding a predator agent to the space, where it selects a specific fish and moves towards the fish, affecting the whole fish swarm organization, and as a sequence, their individual and collective visual information.

The predator is initiated outside the prey collective and moves towards the center of mass of the prey school with the double of their velocity.

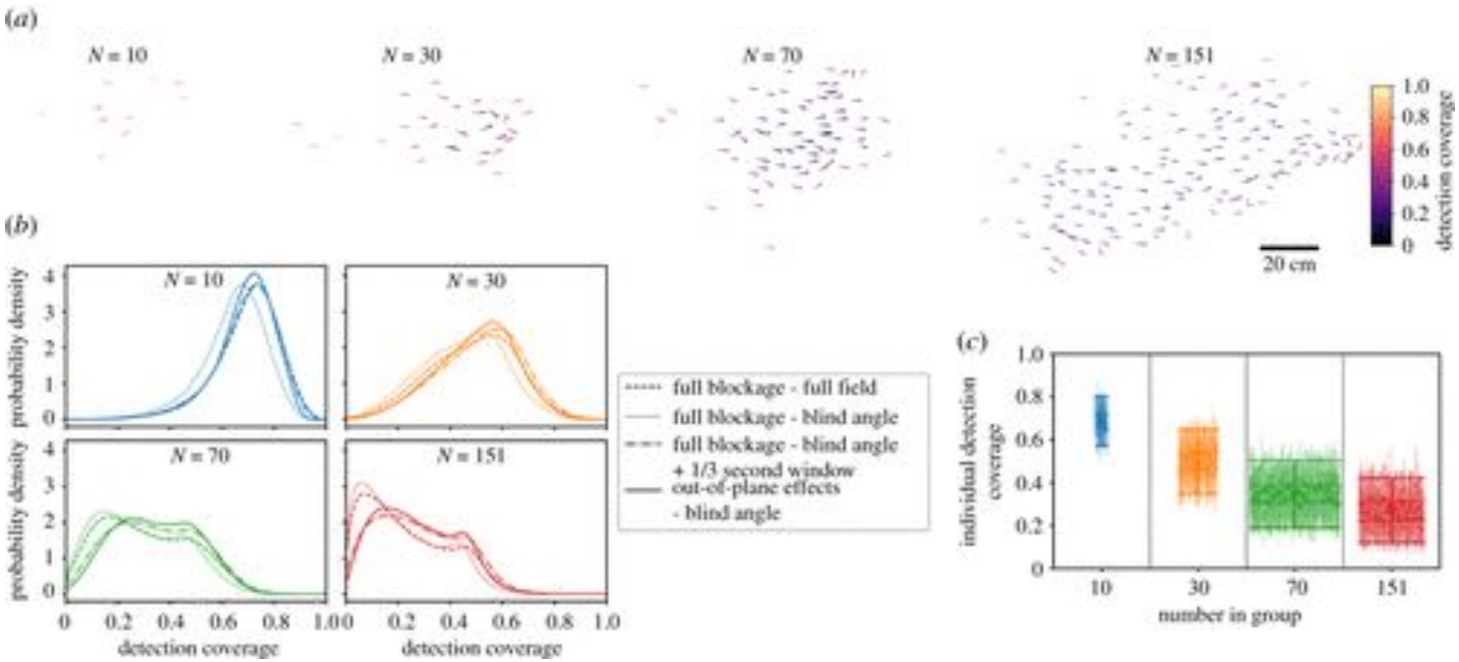
Results

As the **number of individuals increases** the **average detection coverage decreases** resulting from occlusion caused by neighbours and the **variance** of **individual external visual coverage** in the group **increases**.



Results

As expected, **out-of-plane effect** increases the individual's detection coverage, with the largest change for the group with 181 member.



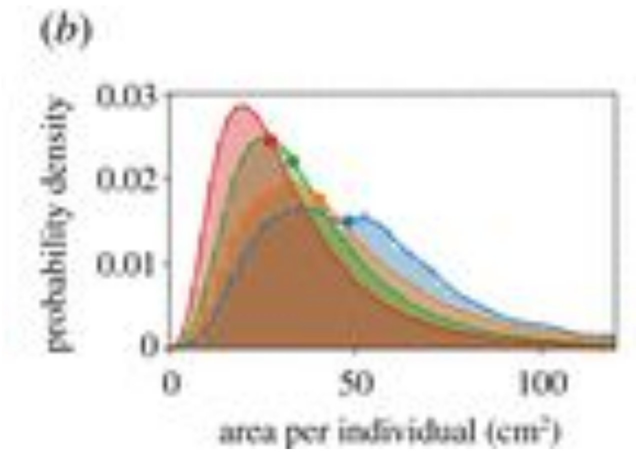
Results

On the other hand, if an individual has detection capability in a given direction at time t if there was visual access in that direction at any time within the previous T seconds, the coverage increases, with the largest effect on the largest group.

So we can conclude that small changes in position over a short period could **reduce** the **decrease** in **detection coverage** caused by having a **blind angle**.

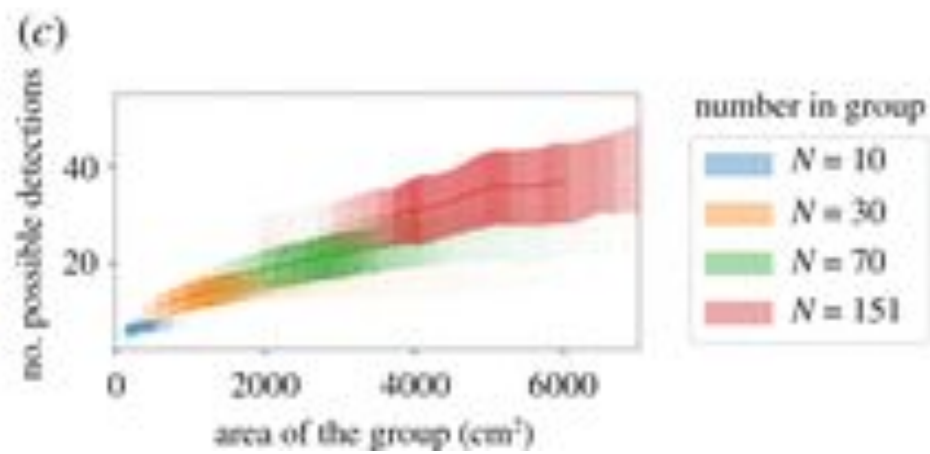
Results

Regarding **collective detection**, groups with more individuals occupy a larger spatial area. However, the median spatial area per individual decreases as individuals tend to pack slightly more tightly when there are more individuals in the group.



Results

In the end, the **external detection** is **higher** when the group occupies a **larger area**, because when individuals more widely spaced, each neighbour blocks less the external view visual field of others.



Results

Regarding the **predator attack**, during the attack, the number of members in each group decreases, as well as their area, which, as seen before affect their individual and collective visual detection.

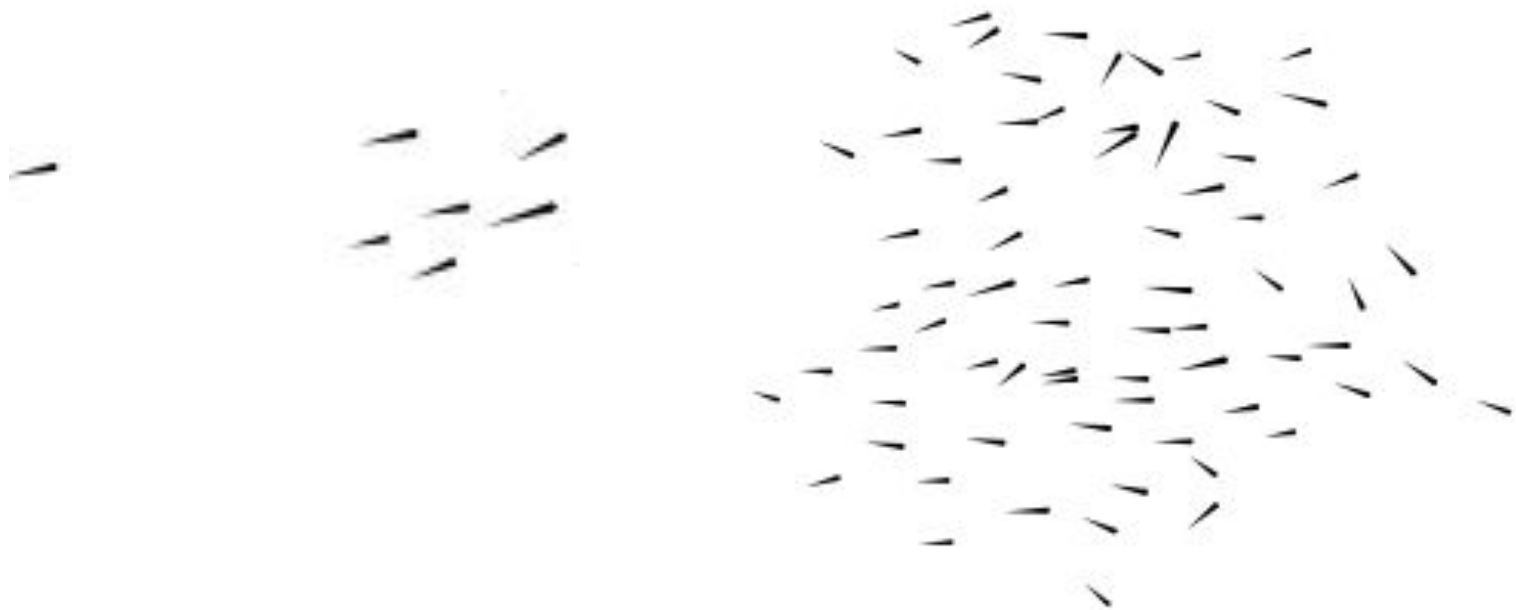
The fishes **individual external visual coverage increases**, but the **variance of visual coverage decreases** and the blind angle is more visible. On the other hand, the **collective external detection** gets **higher**, because the group area is smaller.

Biggest challenges

Challenge	Solution
Understanding fish behaviour	Read and analyse research papers and online articles
Run the source codes since datasets are very large and the programs are intensive	Used a download manager to download; tried to use Google Colab, but failed.
Having a group member quitting the course	Organize our work to do the other member’s part
Learning there’s a difference between group sizes and vision	Researched about personal area of fish and their distance from the group
Trying to integrate the predator algorithm	Researched several papers and analysed their source codes, but was not well succeeded

What would we do differently

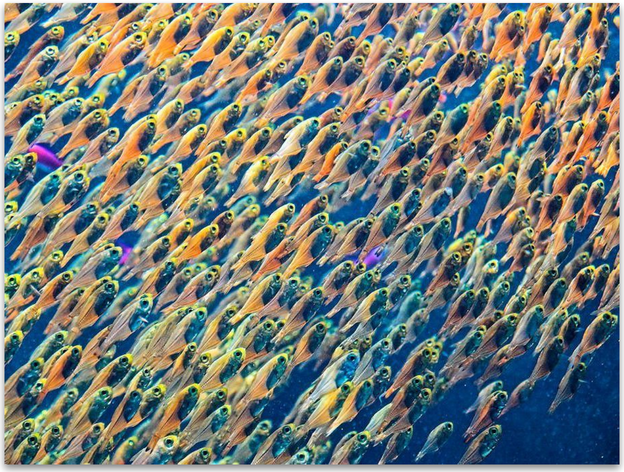
- “Pool of competence” effect



- the bigger the group, the higher the probability that there exists an individual that will detect an object

What would we do differently

- Run simulations with tighter groups



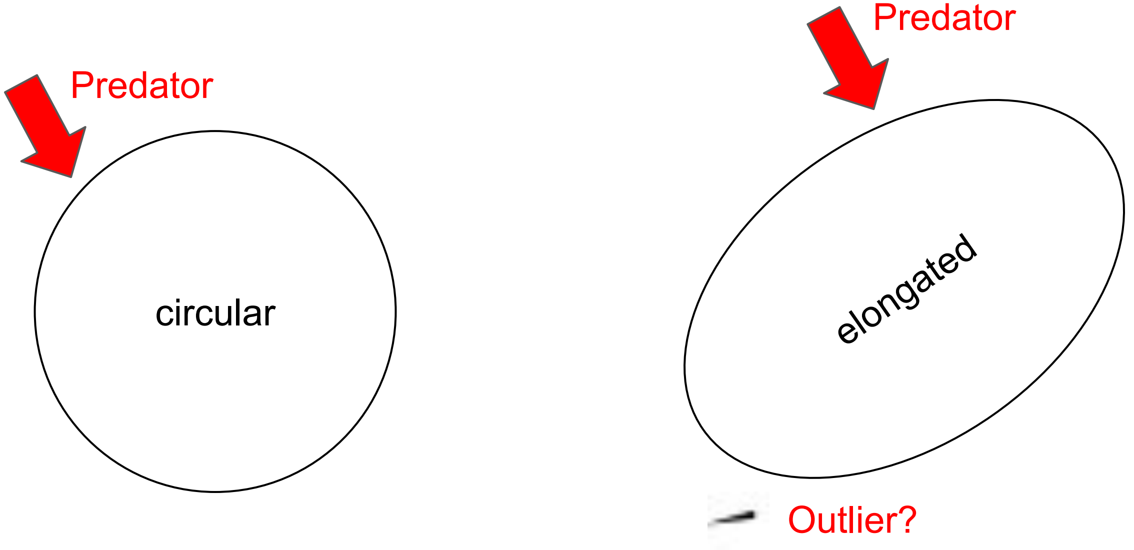
https://www.thesprucepets.com/schooling-fish-1378344

https://twitter.com/nakaweproject/status/1205169378574176256

- The tighter the group, the higher the probability of reacting to a neighbor
- What would be the success if the school was hyperreactive?

What would we do differently

- Account for group shape



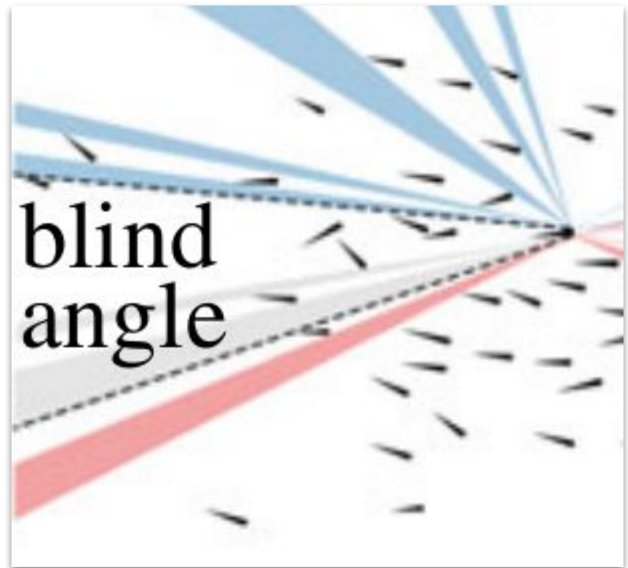
- Account for specific differences using agent-based modelling
    - Analyze individual reactions on different shapes

What would we do differently

- Supplement the 25° blind angle

https://www.petmd.com/fish/care/all-about-mexican-tetra-history-blind-cavefish

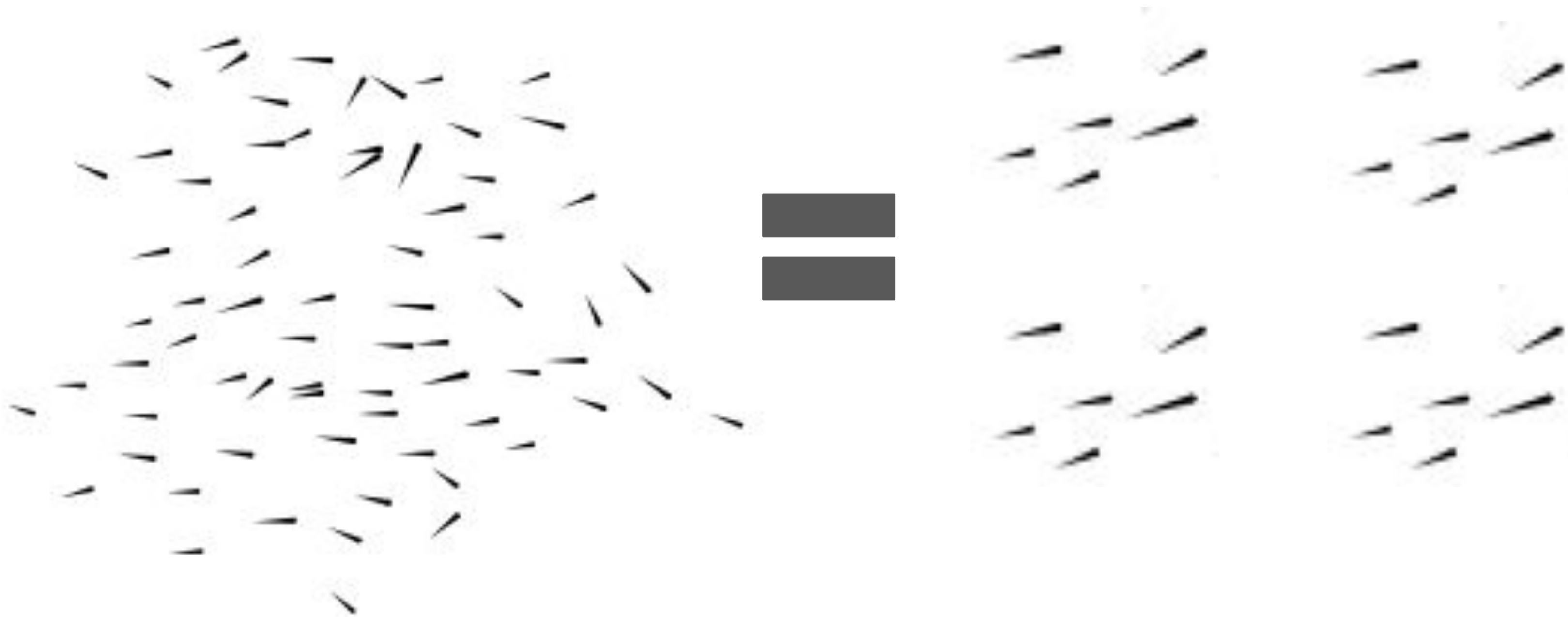
Blind Cave Fish can react to movement without using vision



Can we use this to make up for the missing vision in Golden Shiners?

What would we do differently

- Separate schoolings



- Groups of 30+ will have individuals that won't detect predators
- Simulate smaller schools and evaluate success rate

References

[1] Lima SL (2003) Back to the basics of anti-predatory vigilance: the group-size effect.

[2] Davidson JD et al. (2021) Collective detection based on visual information in animal groups. Journal of The Royal Society Interface 18(180):20210142