Reverse engineering: a machine vision solution for aquaculture

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Application of Sensors in Precision Aquaculture

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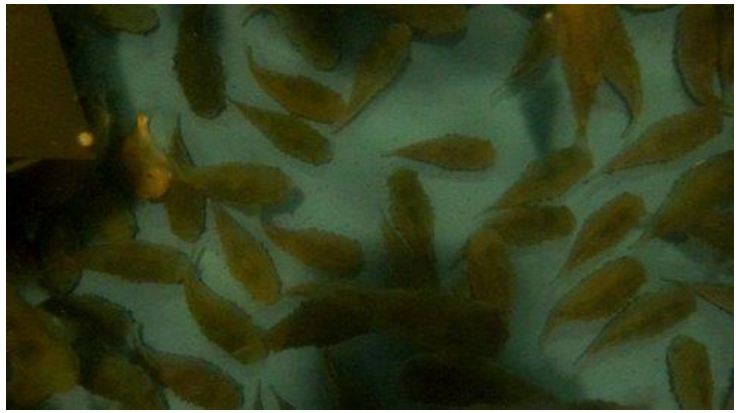
Introduction

- Machine Vision
- Industry questions
- In this presentation
  1. Where do the fish go?
  2. Can clinging and swimming behavior be identified?



1. Where do the fish go?

Start from:

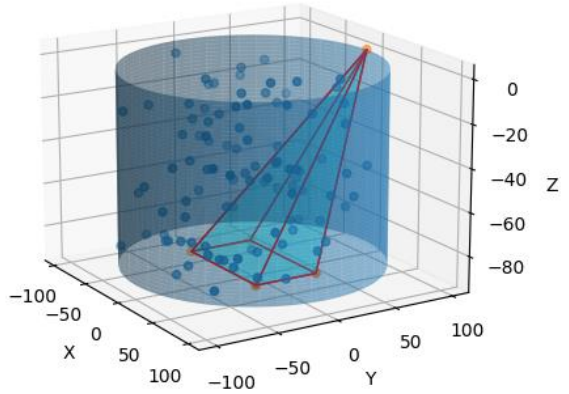
- visual representation

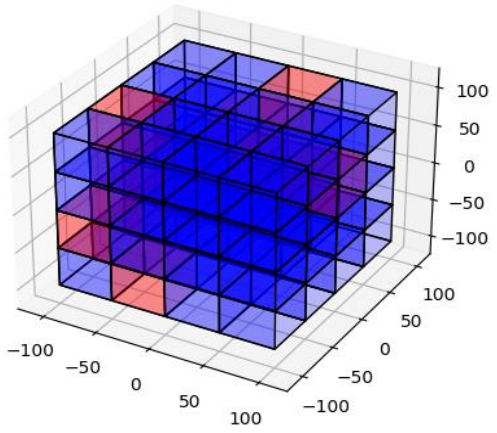
Gives insight:

- fish behaviour
- distribution in the water volume

Indicates:

- e.g. fish aggregating to the surface can suggest low oxygen level





The process in reverse:

7. record underwater videos and detect fish in frames
6. define the position of individual fish in 3D space - (x, y, z) coordinates
5. distribute the total volume in small units
4. calculate the number of fish inside unit volumes
3. calculate the average fish number in each unit
2. define a threshold for critical fish density
1. visualize the results

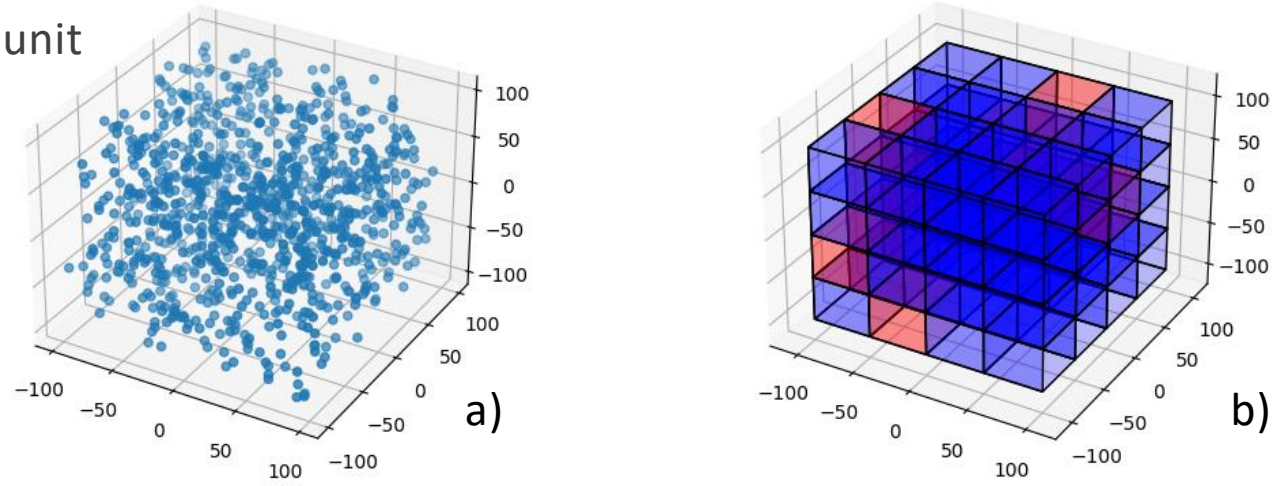


Fig. 1
a) Uniformly randomized position of 1000 fish in 200x200x200 m^3 volume.
b) Unit volumes, colored based on the number of fish in volume.
Red – high density-more fish, blue – low density – less fish

Employing machine vision

DETECT FISH

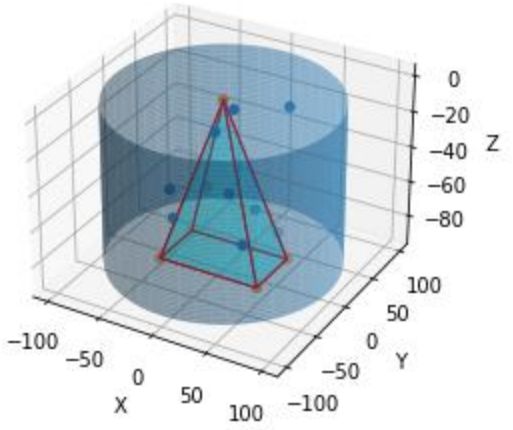
- AI - Deep Learning algorithms
- Fish position in the image 2D (pixel coordinates)

DEFINE POSITION IN 3D

Stereoscopic images are used in the recordings.

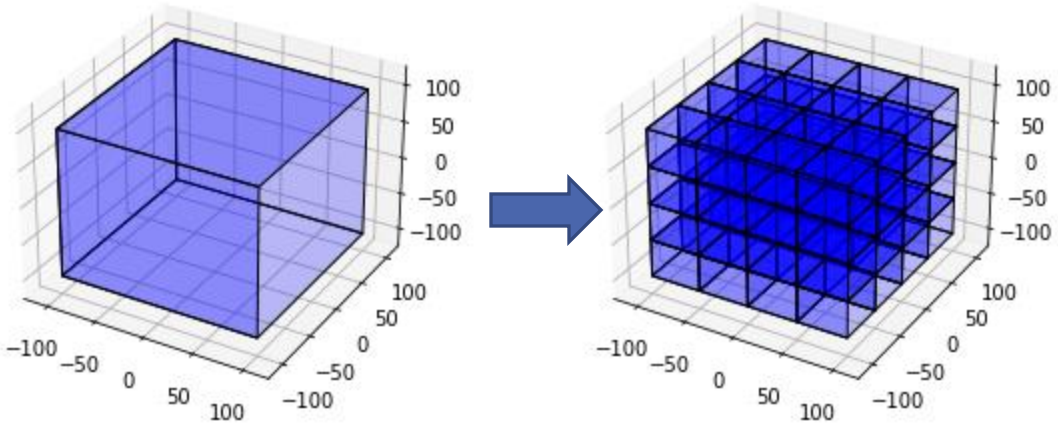
We can calculate the (x, y, z) coordinates of the detected fish.

We can visualize the position of the fish inside the tank.



Simplifying the results

DIVIDE THE TOTAL VOLUME

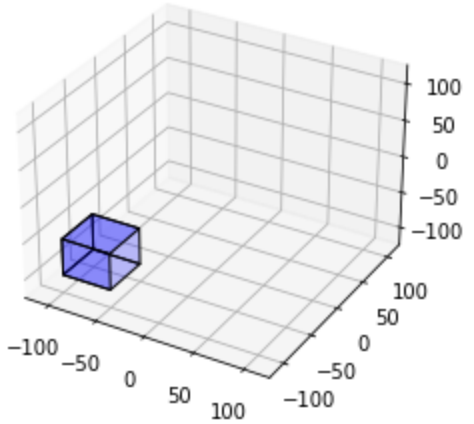


- distribute the total volume in small units – 50x50x50 m units

```
u_x, u_y, u_z = 50, 50, 50
units_x = int((x_max-x_min)/u_x)
units_y = int((y_max-y_min)/u_y)
units_z = int((z_max-z_min)/u_z)
```

FISH IN UNIT VOLUMES

- Unit volumes are determined by the coordinates of the vertices.




```
[[-100,-100,-100],
[-50, -100, -100],
[-50, -50, -100],
[-100, -50, -100],
[-100,-100,-50],
[-50, -100, -50],
[-50, -50, -50],
[-100, -50, -50]]
```

- The positions of the fish are known.

- Counting the number of fish, when its position is inside the unit volume
  (e.g. [25, 20, 36, 14, 22, …])

Simplifying the problem

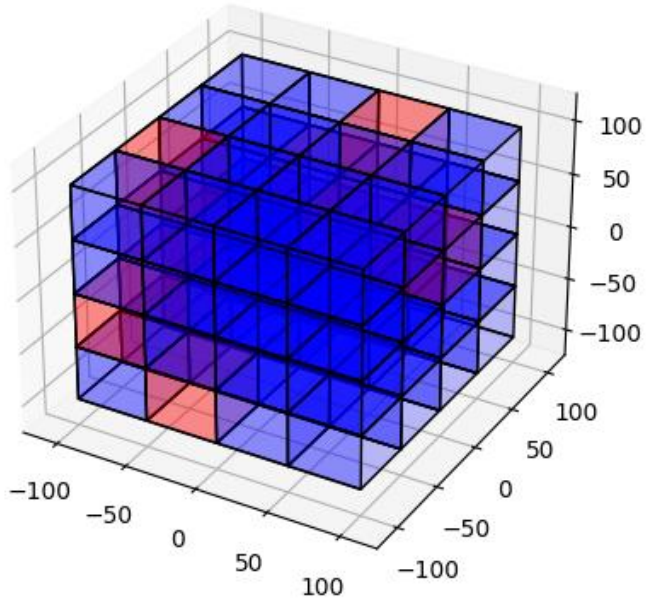
AVERAGE FISH DENSITY IN UNIT VOLUME

- save historical data about counts inside unit volumes

- calculate the average number for a given period (e.g. 20 min)

- mark visually if the number of fish is high in a specific part of the water

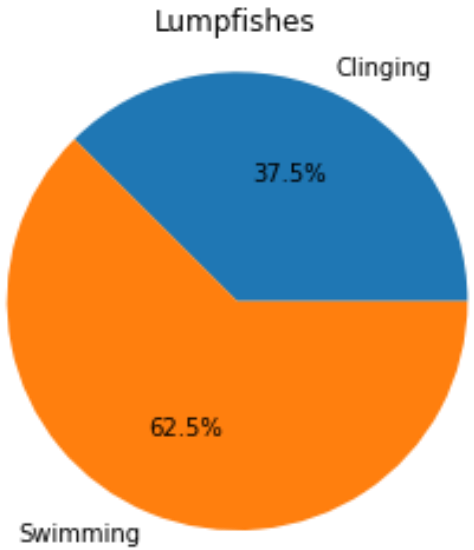
VISUALIZE THE RESULTS



2.Clinging and swimming behavior

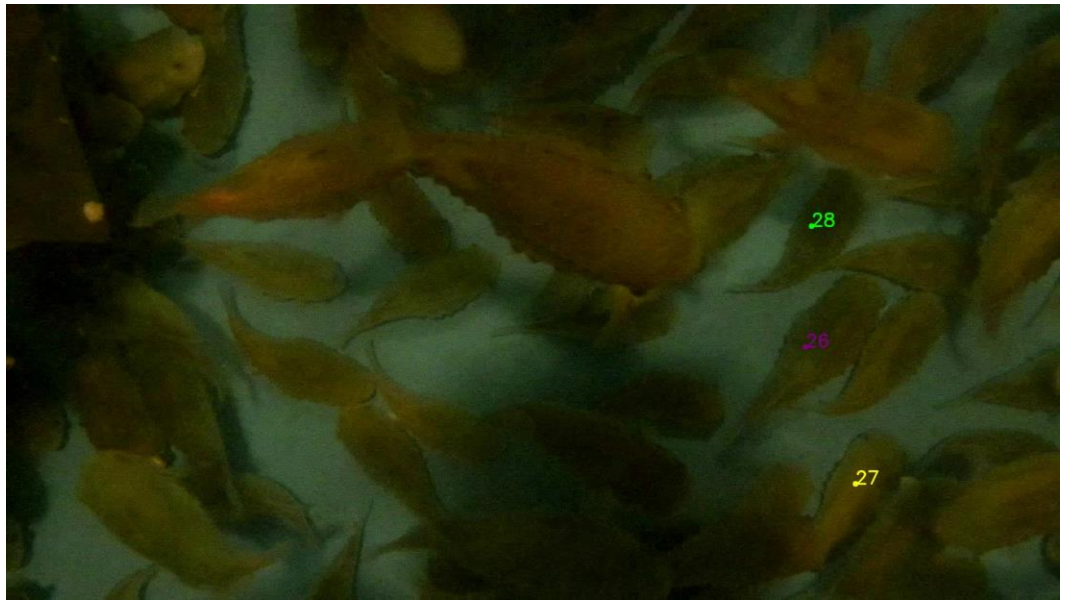
What we want to see

- Blue – amount of fishes clinging represented in %
- Orange – amount of fishes swimming represented in %

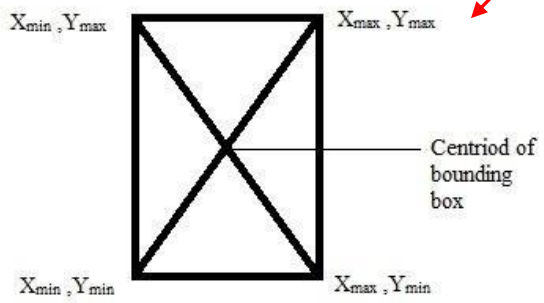


The process in reverse:

7. record underwater videos and track fish in frames
6. define the initial position of fish where the centroid shows up
5. in next frames identify again the fish/fishes position and compare with previous one
4. fish swimming : compare new position of lumpfish with last position , if not equal -> lumpfish moves
3. fish clinging : compare new position of lumpfish with last position , if equal -> lumpfish doesn't move
2. count fish swimming and fish clinging
1. visualize the results

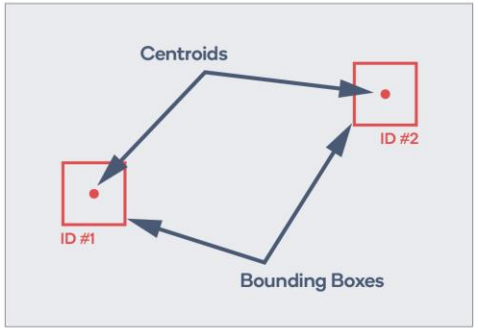


Fish detection

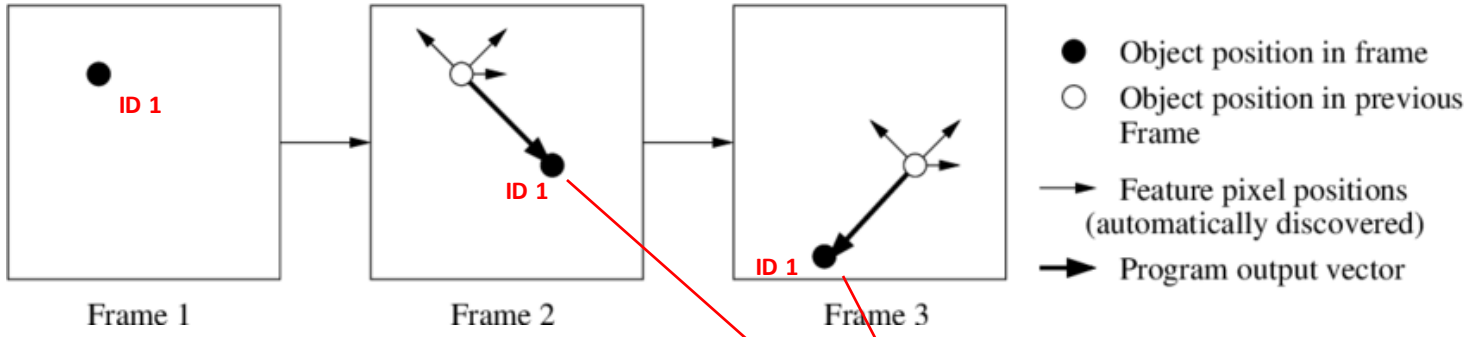


As input for tracking, we used the output of Deep Learning algorithm (detections of lumpfish)

Calculate centroid of each detection and give a unique id

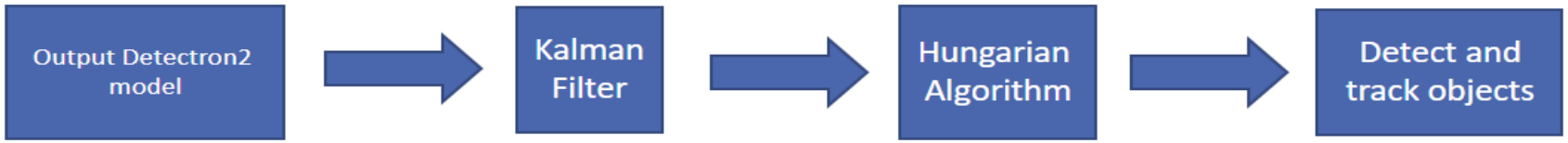


Fish tracking



Apply Kalman filter [1] – predicts new position based on historical positions

Hungarian Algorithm[2] - validates if an object in current frame is the same as the one in previous frame



Clinging vs swimming behaviour

Estimating behaviour types:

- Fish swimming:

  Previous position of fish detected is not equal to the new position.

- Fish clinging:

  Previous position of fish detected is equal to the new position.

Example for distinguishing behaviour:

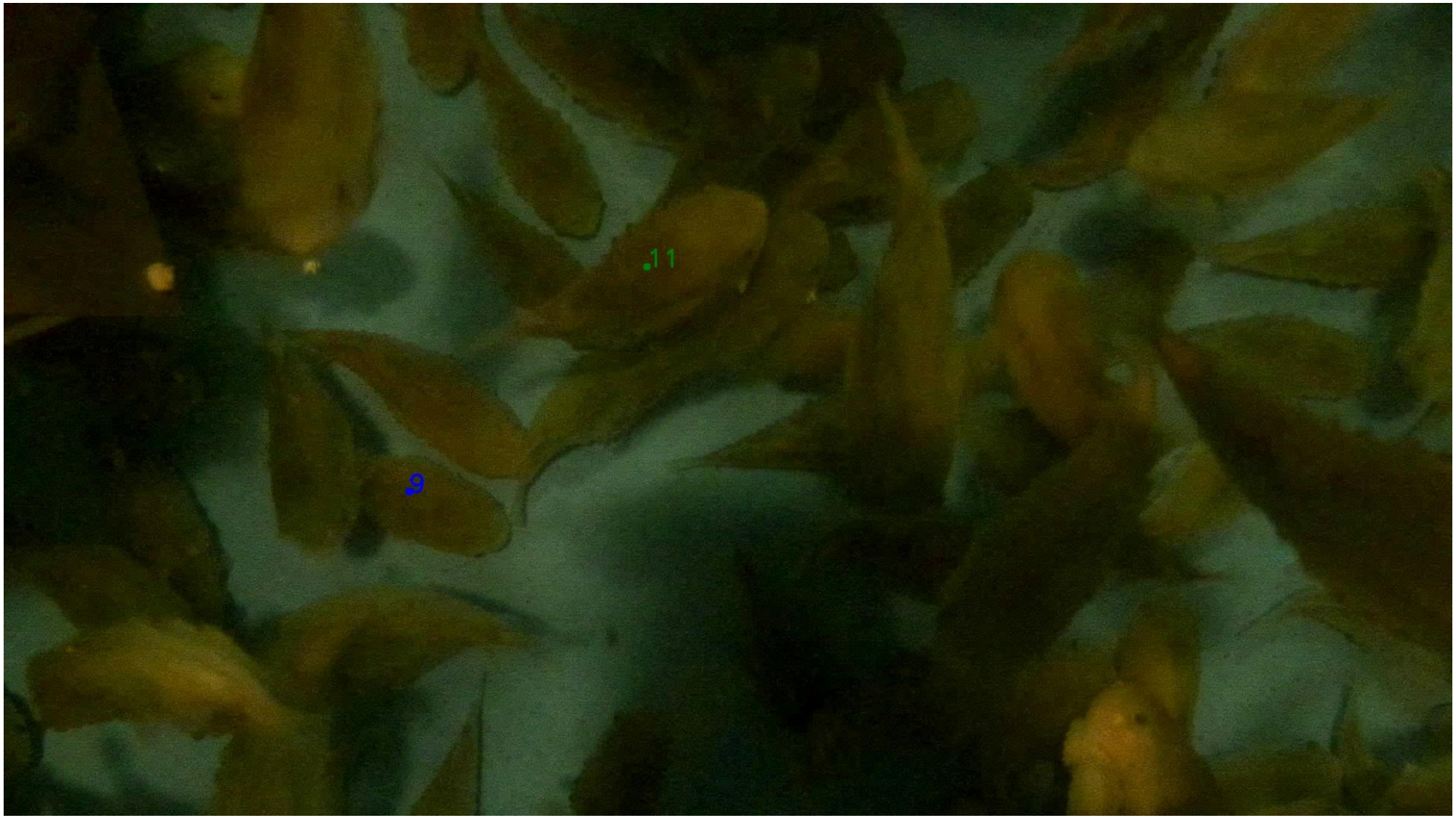
Lumpfish 9 : in initial frame was found at 28.33 pixels and next frames the same at 28.33 = lumpfish clinging

Lumpfish 11: in initial frame was found at 31.59 pixels and next frames at 25.74 = lumpfish swimming

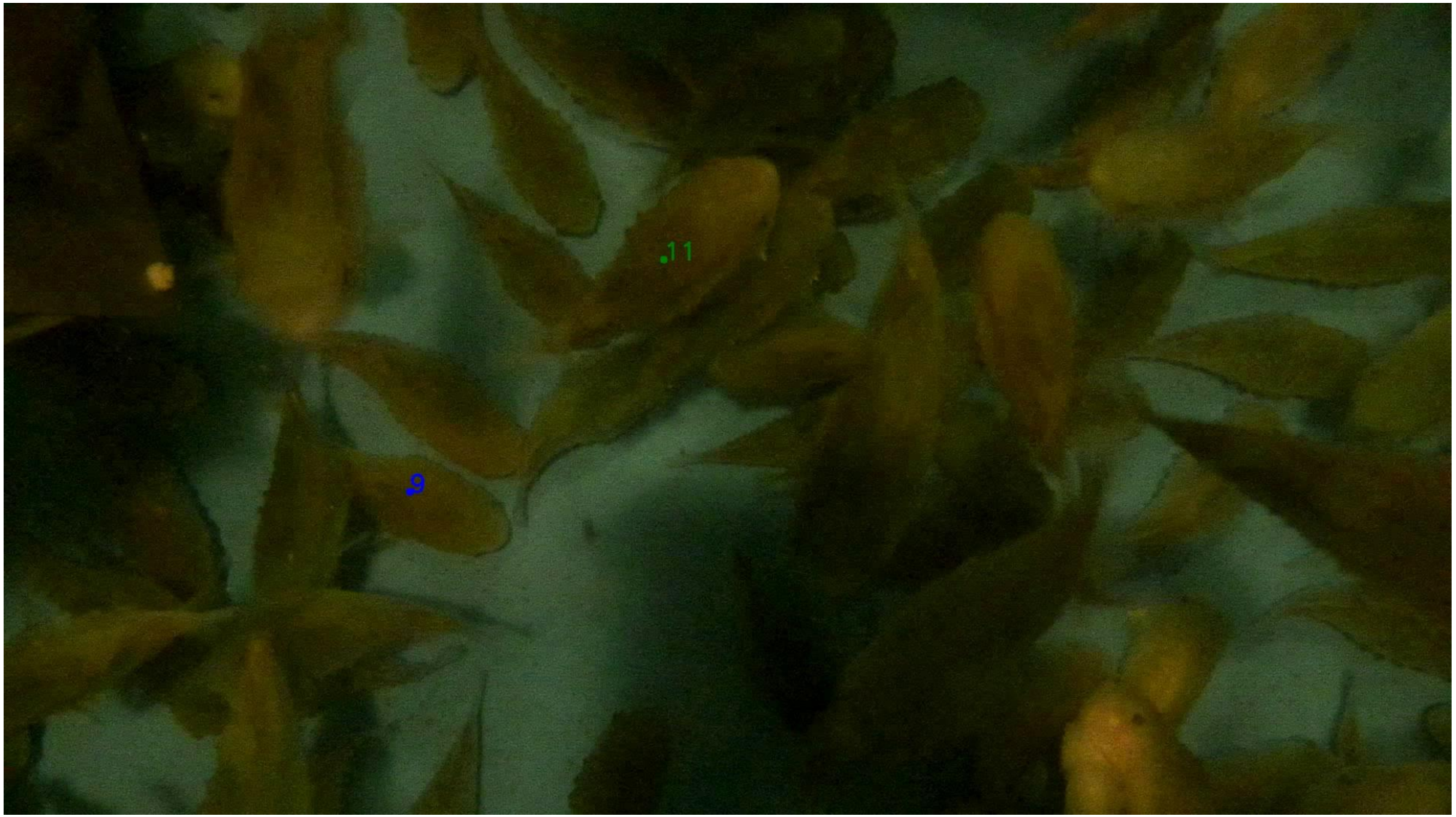
We represent an example in the following images.

Clinging vs Swimming

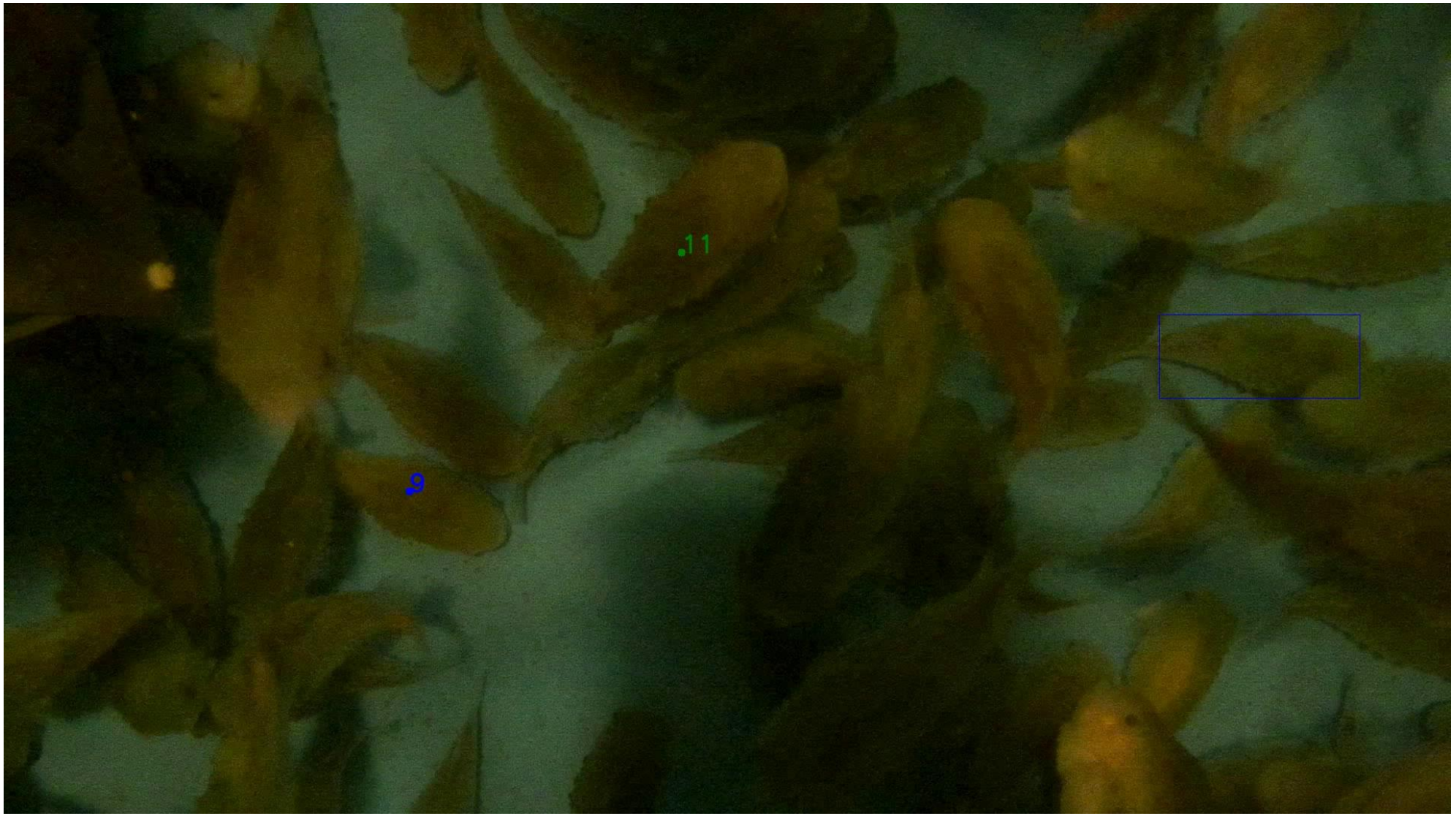
Clinging vs Swimming



Clinging vs Swimming



Clinging vs Swimming



Summary

- Machine Vision is here (technology is available)
- Next steps (focusing more on behaviour analysis)

Advantages

- Always available
- Non-invasive
- Predictive

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