NSTRUCTION

Using plankton as biosensors

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NSF Center for Cellular Construction

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csf.edu

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Outline

tion and Problem Statement

description and acquisition

vised learning pipeline

engineering

morpho-dynamical chemical response

on

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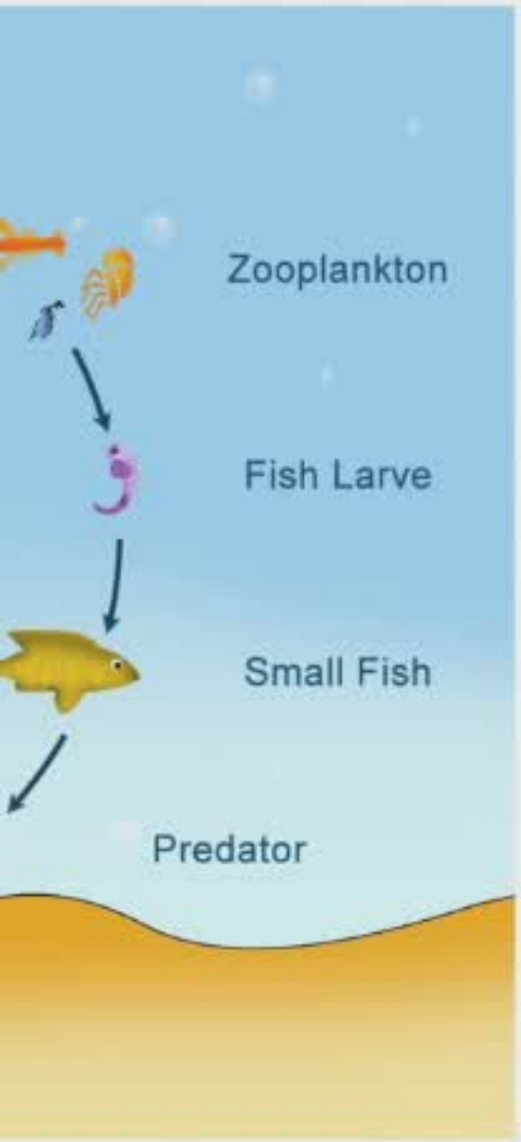
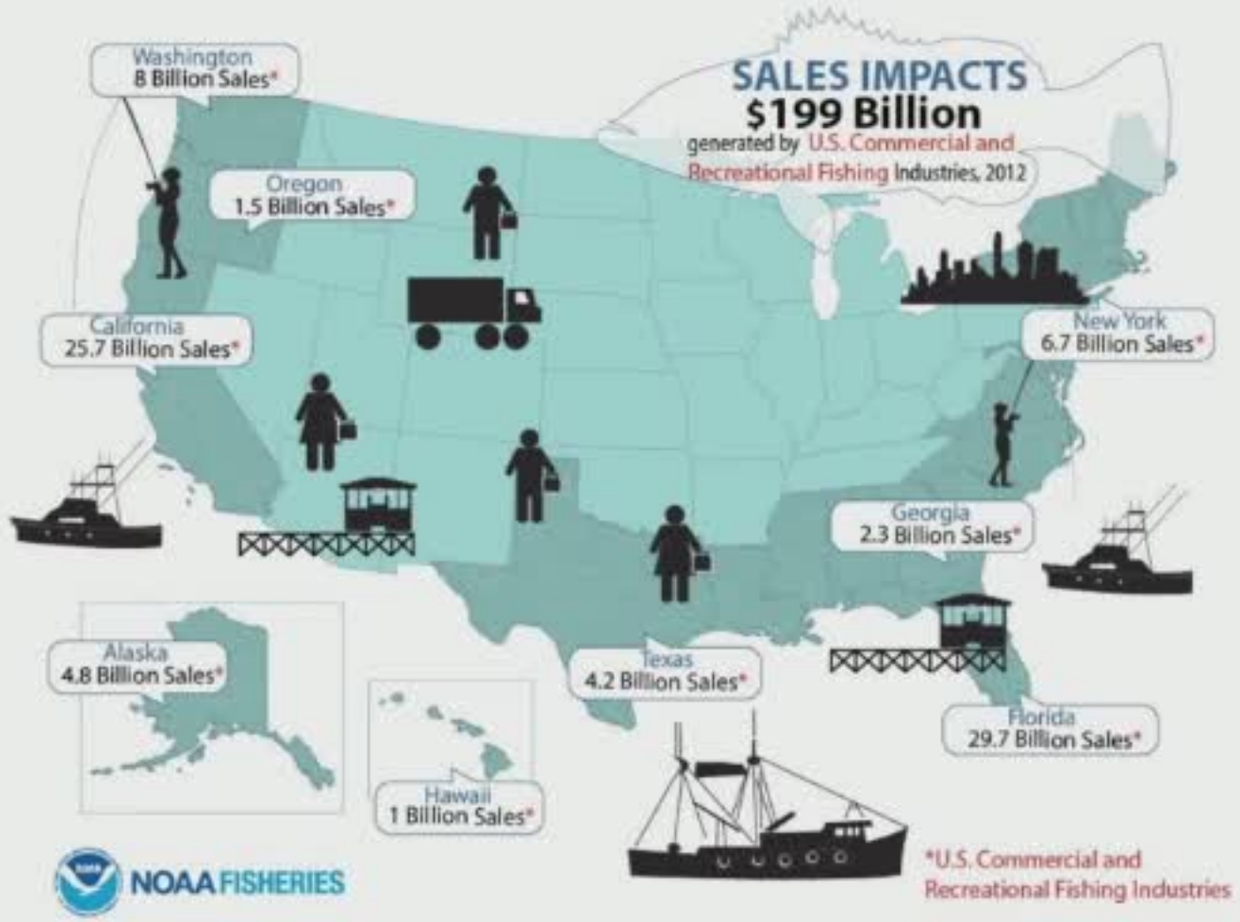
The importance of plankton

is the first animal source of protein for 1 billion of people





plankton has produced 50-70

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Problem Statement

Can plankton be used as environ
monitor, and hence biosens

↓

Establish a morphological and dyna

↓

Biosensor feedback coming fro
from the baseline

↓

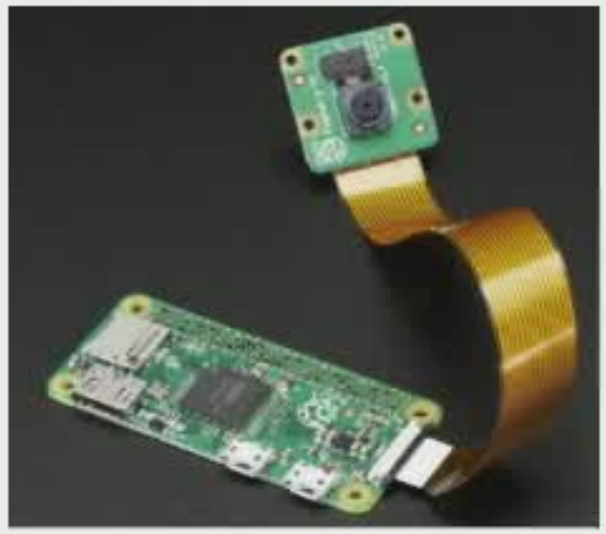
Design a mathematical model for
plankton

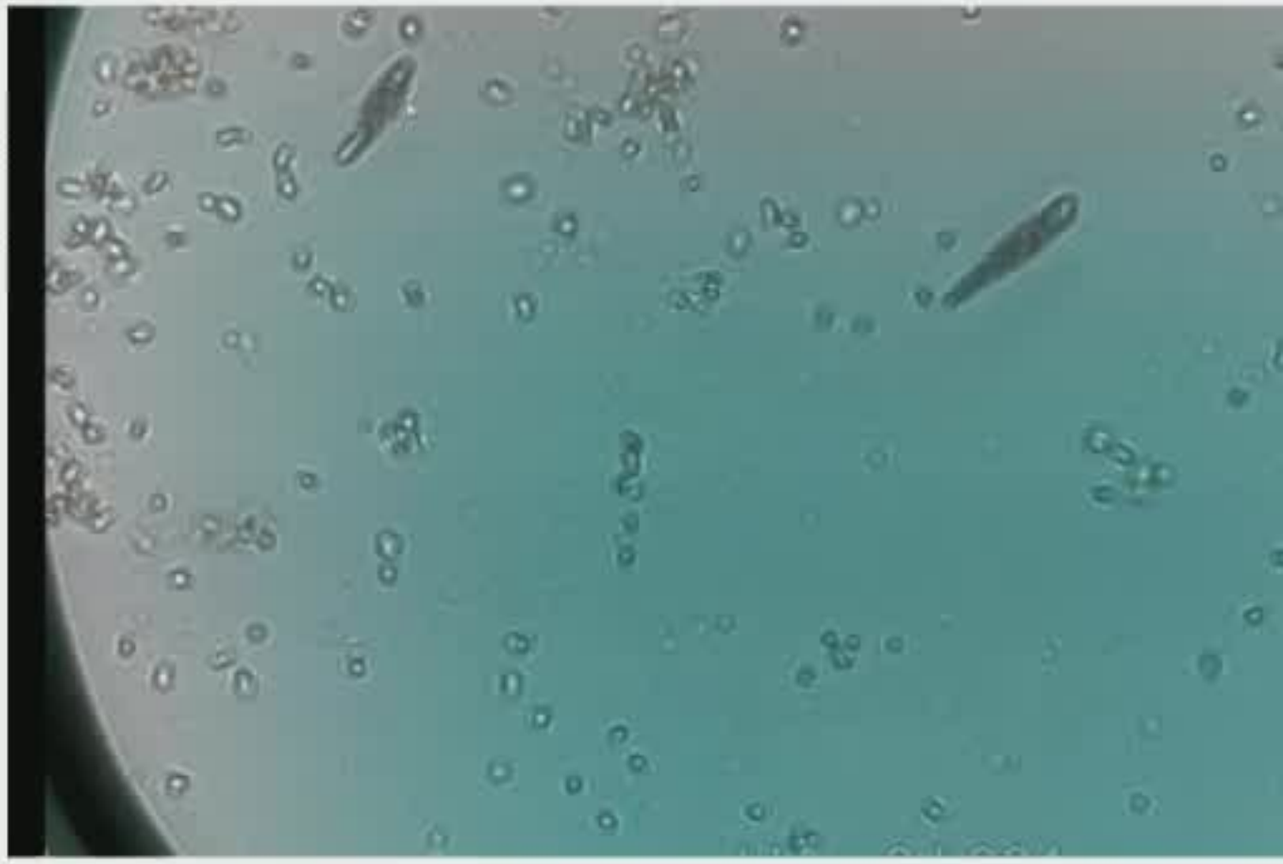
Experimental setup (1)

Bluetooth $10
$40

a (V1) $7
age Sensor
2.7 mm area
el

essor
ce
Python, OpenCV
put





omas Zimmerman et al., 2019, Stereo in-line holographic digital microscope, SPIE Proceedings Volu
883

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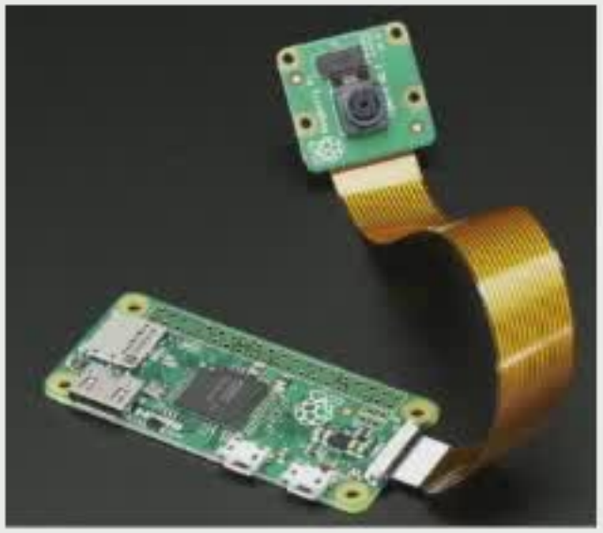

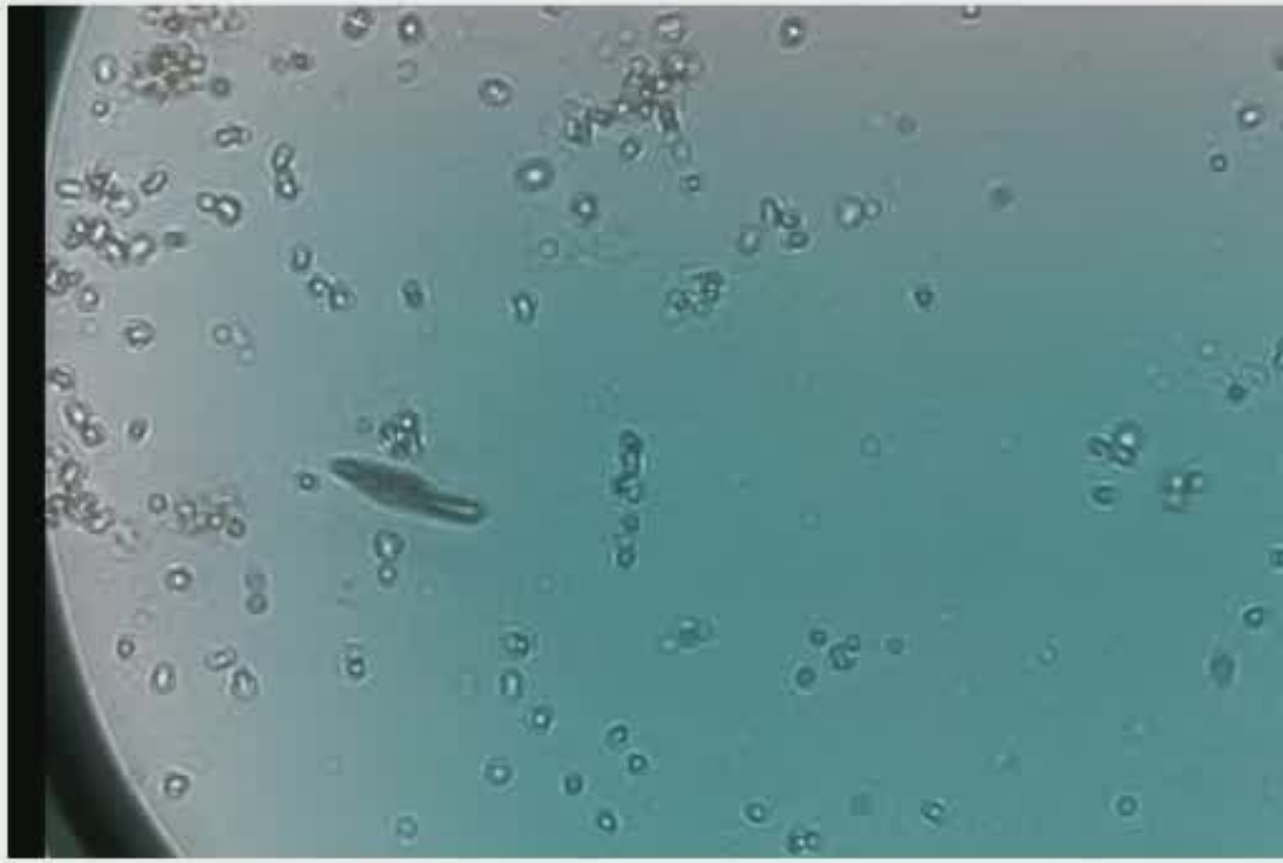

omas Zimmerman et al., 2019, Stereo in-line holographic digital microscope, SPIE Proceedings Volu
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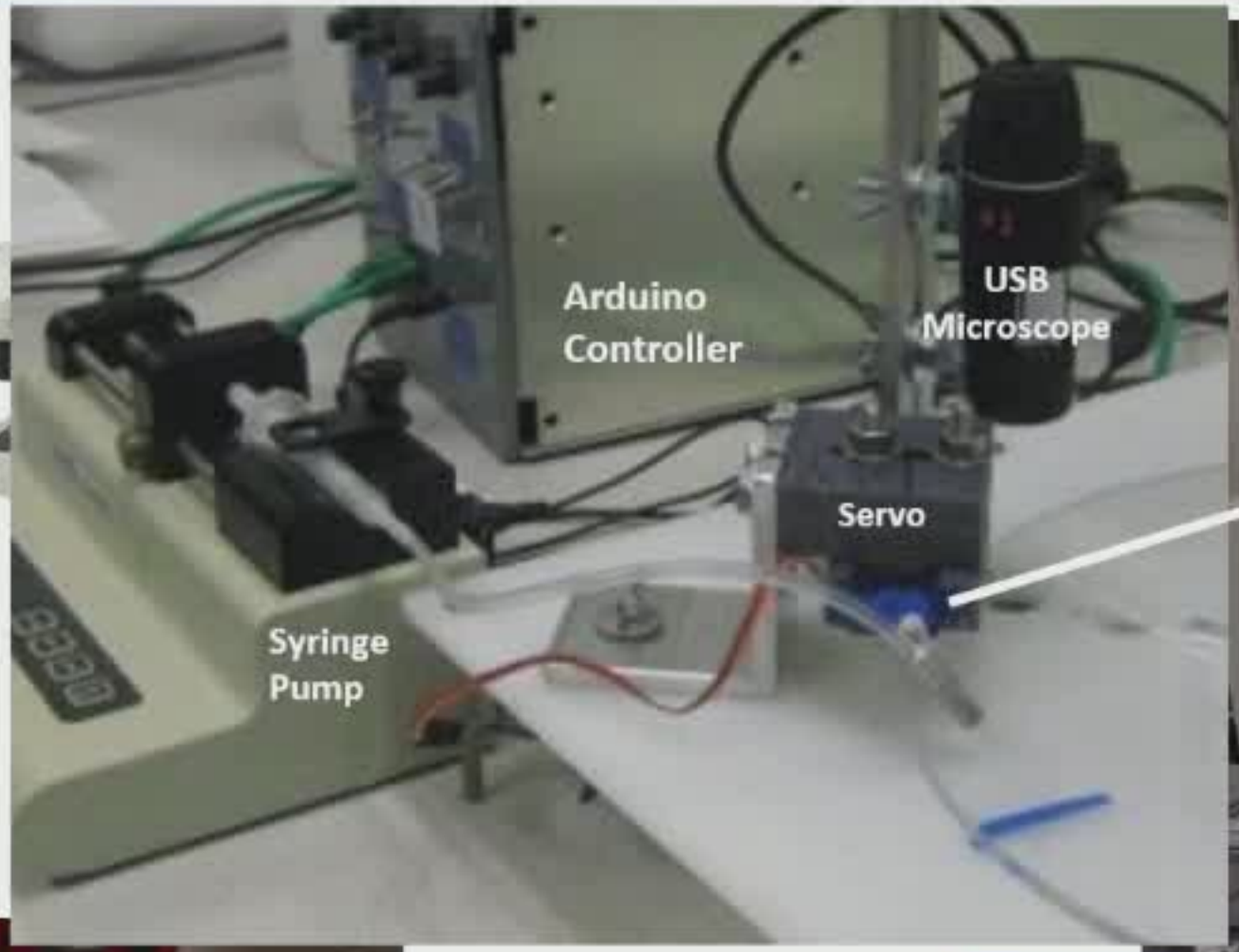
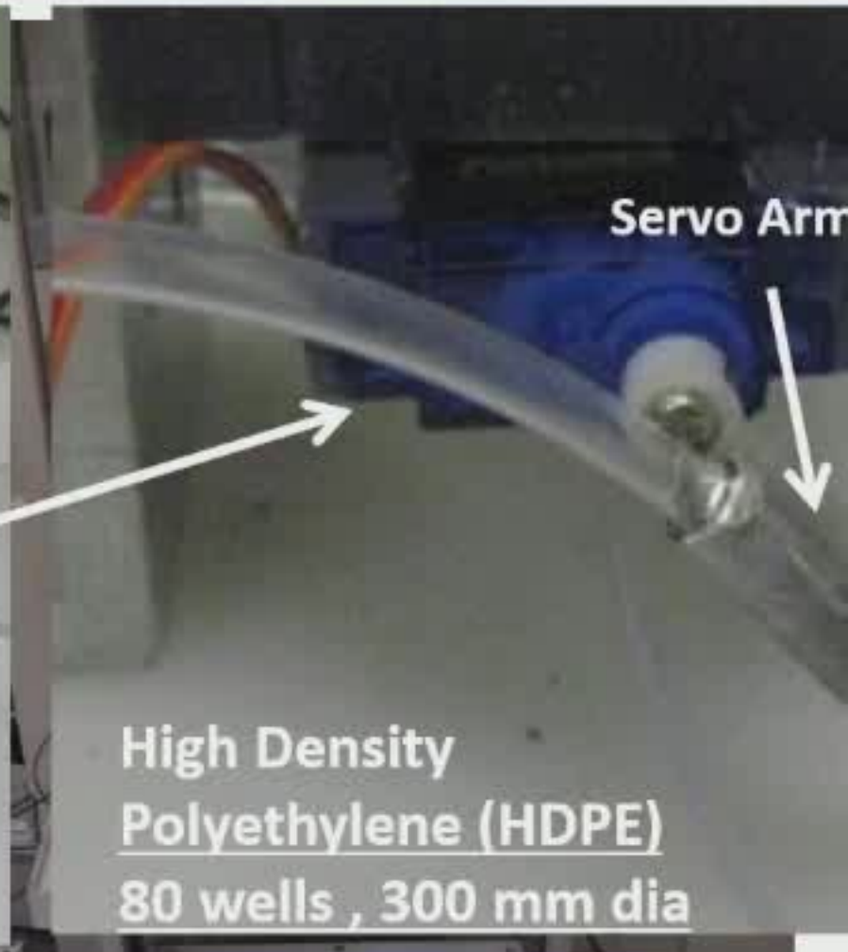
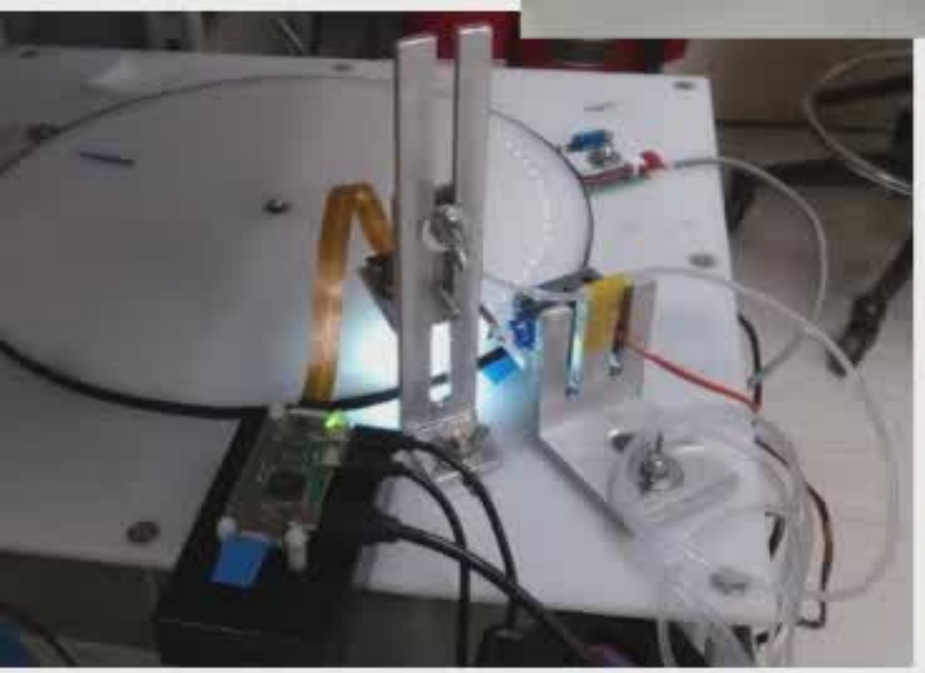
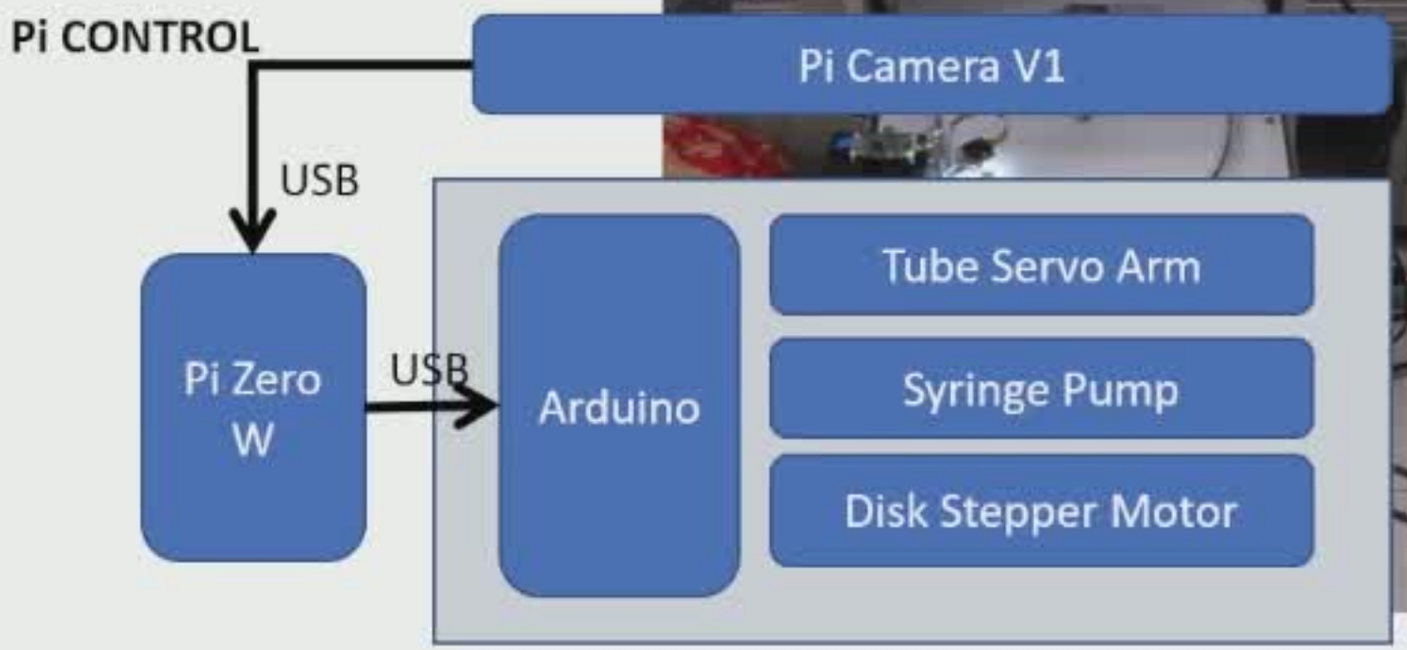
Experimental setup (2)

Drop Microscope









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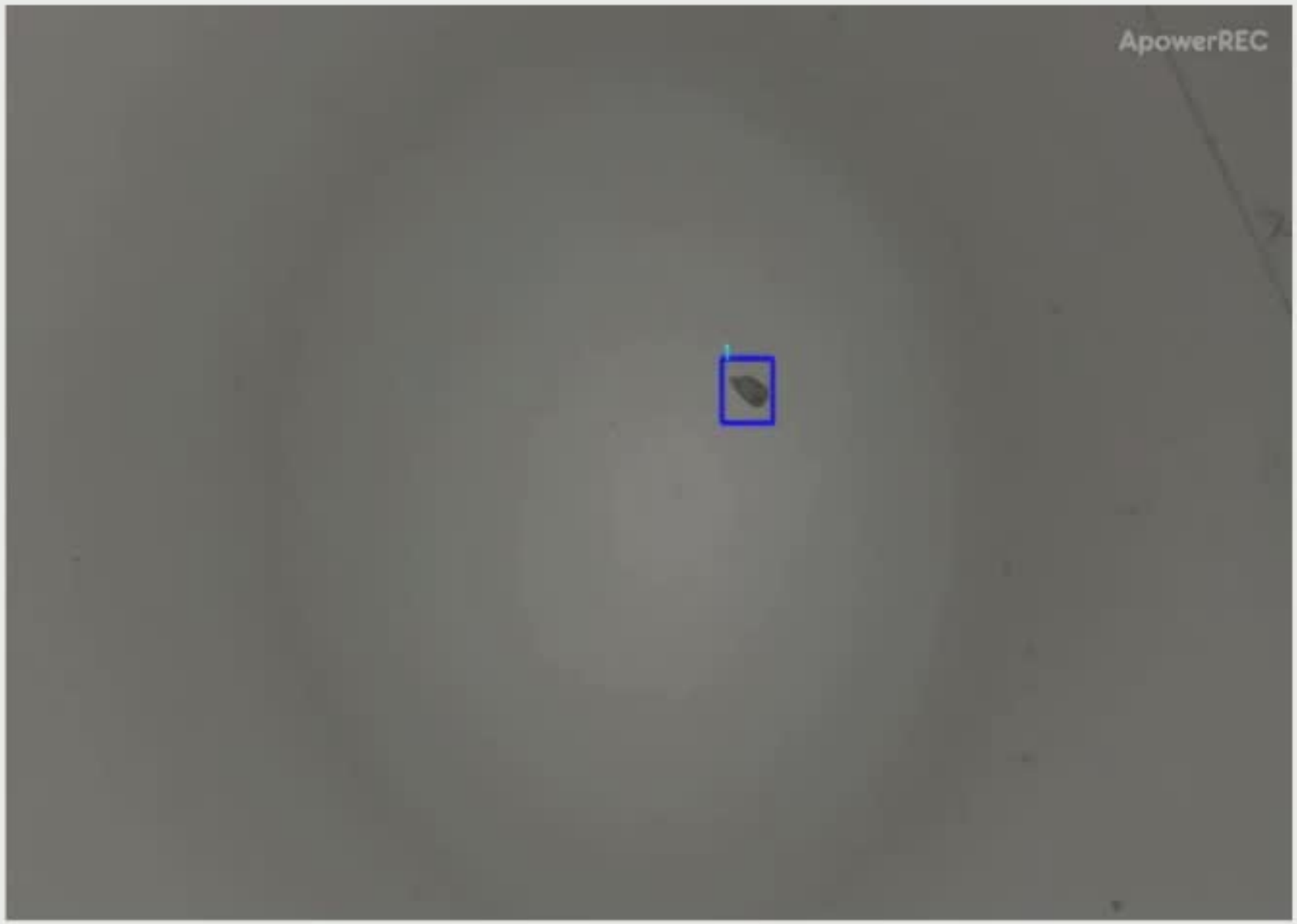
Example of video



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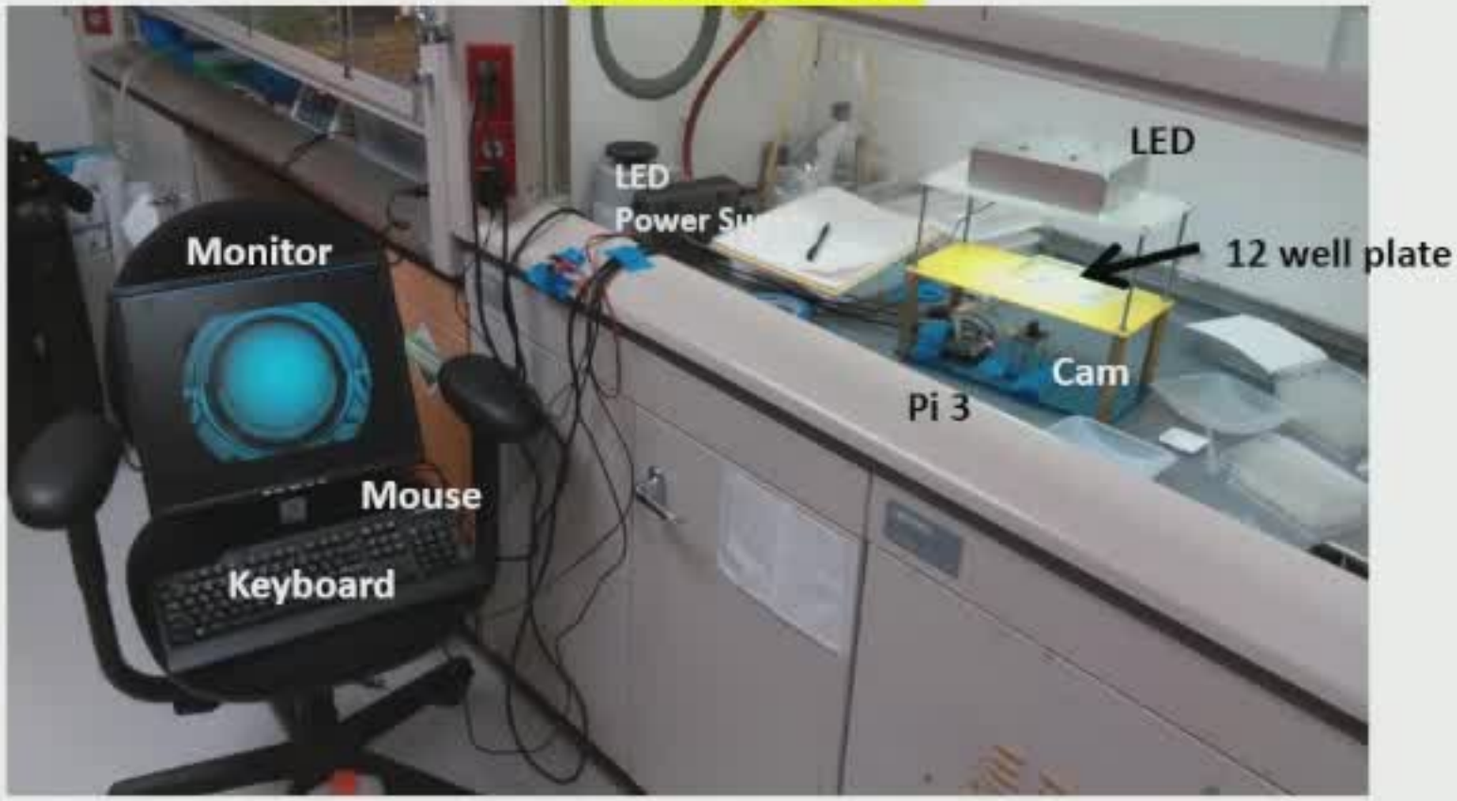
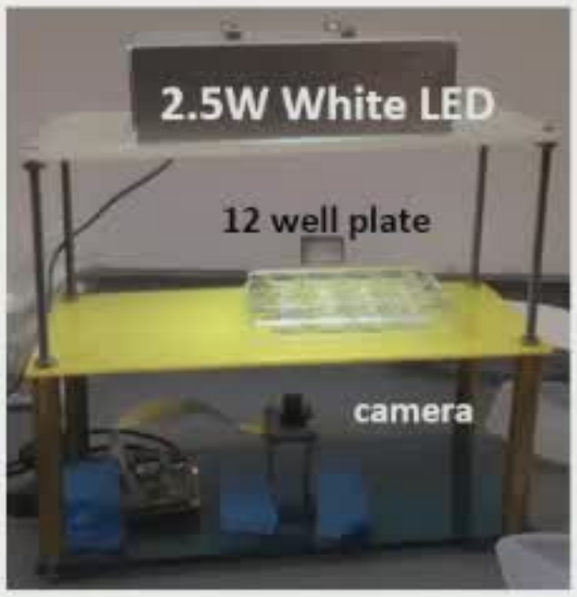
Experimental setup (3

Plate Cam





12 well plate filled with Stentor and Chemical

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Example of video

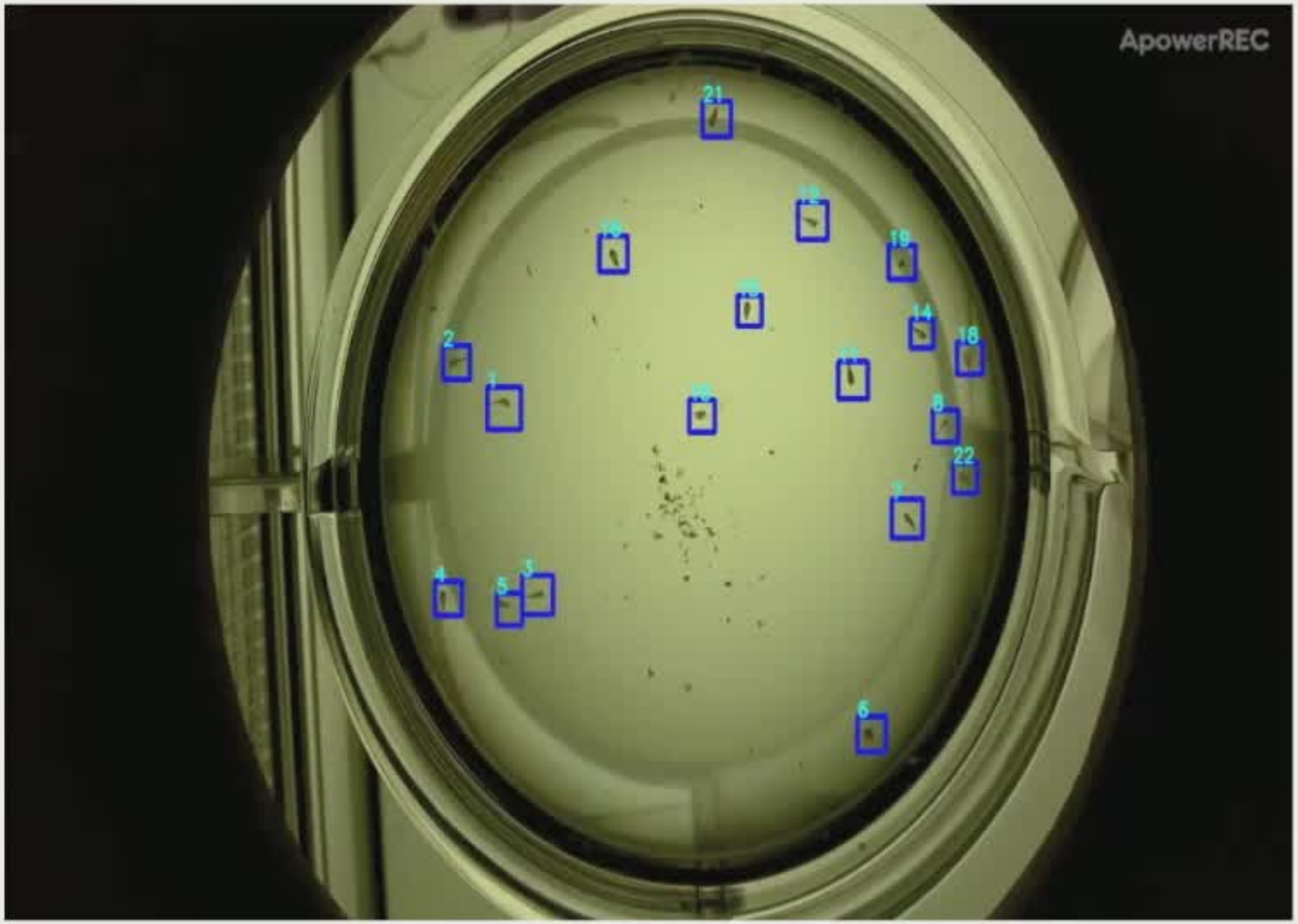

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Image processor

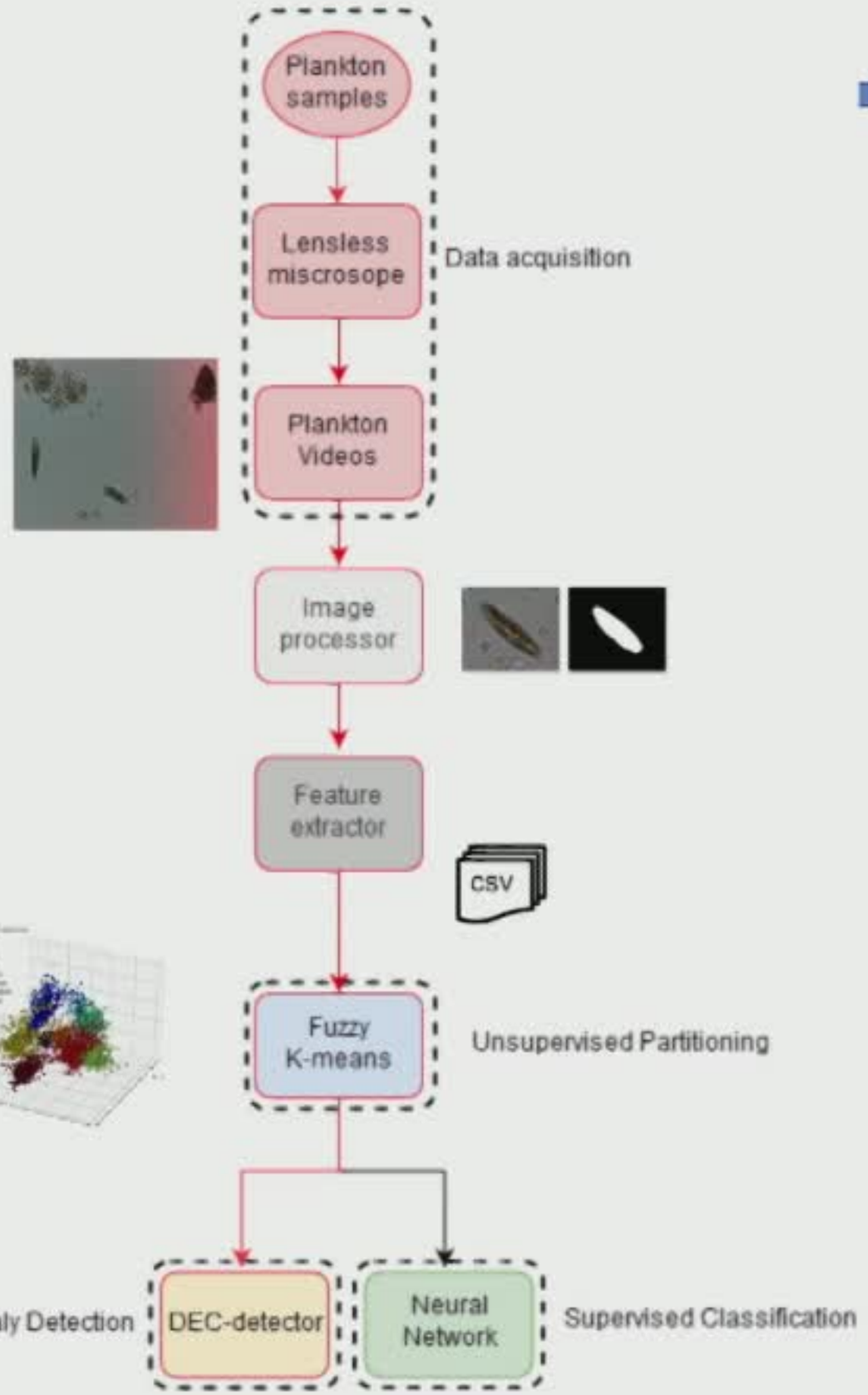

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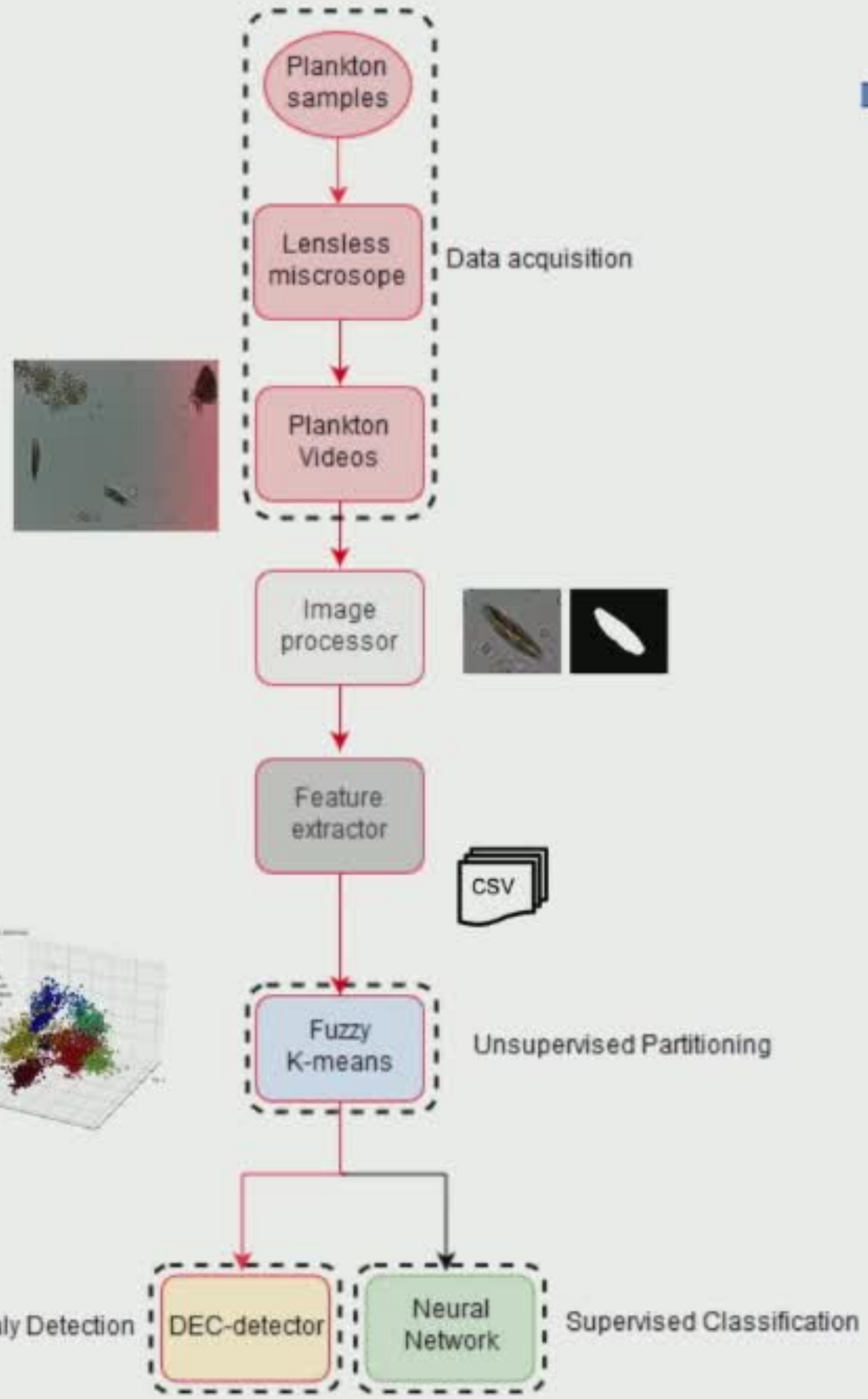
Image processor

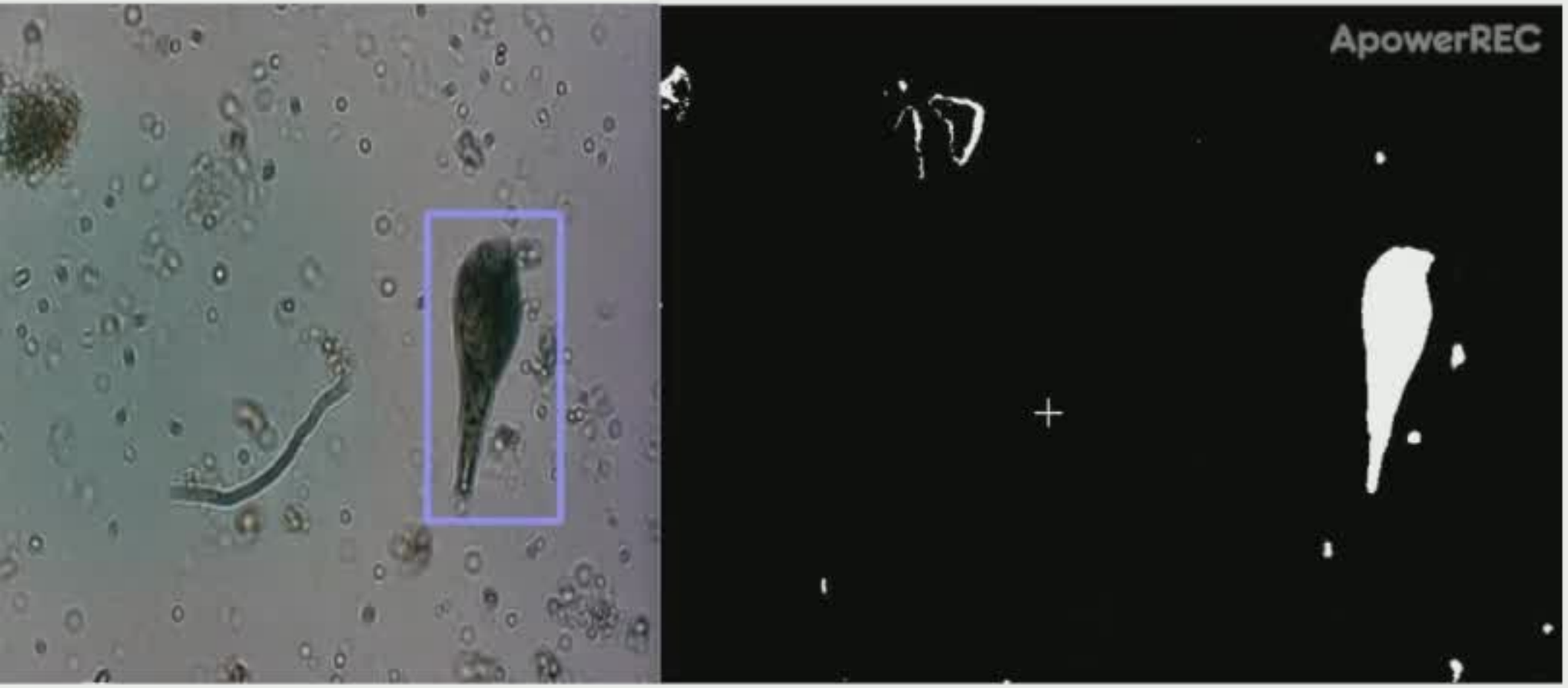


Detection and tracking

ing
ground subtraction
rization
ng
our extraction

OpenCV Python

See poster *Encoding plankton beha*
For environmental health monitorin
Sujoy K. Biswas (PP2).



Detectio
Tracki

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Lensless microscope results

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Lensless microscope results

Testing the morphological features

al., 2019 Annotation free learning for plankton classification and anomaly
Nat Mach Intel, under review

5000 Training Images
1400 Testing images

A	**'DILEPTUS'**
B	'ACTINOSPHAERIUM NUCLEOFILUM'
C	'SPIROSTOMUM AM
D	'STENTOR COERULE
E	'ARCELLA VULGARIS
F	'VOLVOX'
G	'EUPLOTES EURYSTO
H	'PARAMECIUM BUR
I	'DIDINIUM NASUTU
J	'BLEPHARISMA AM

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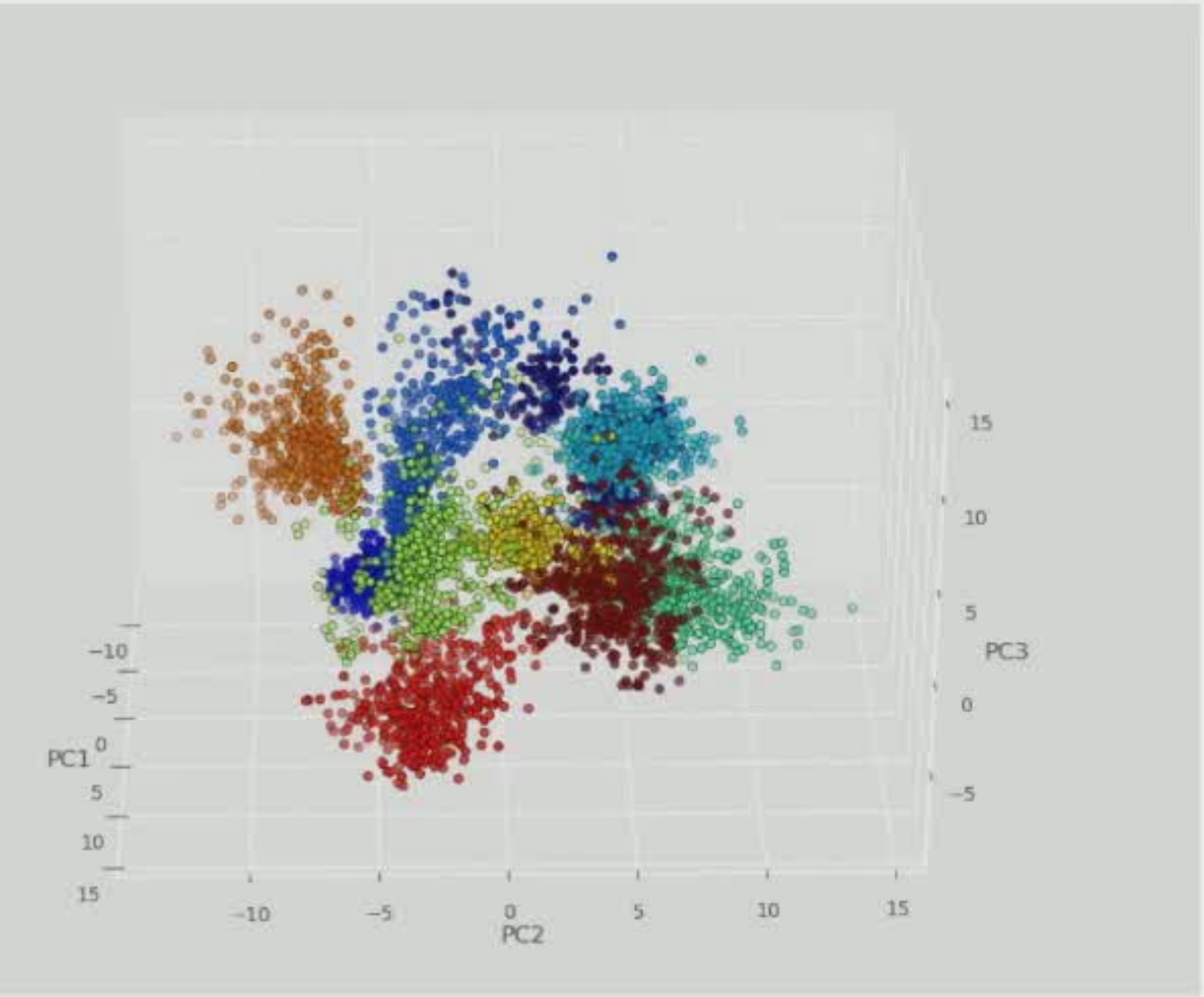
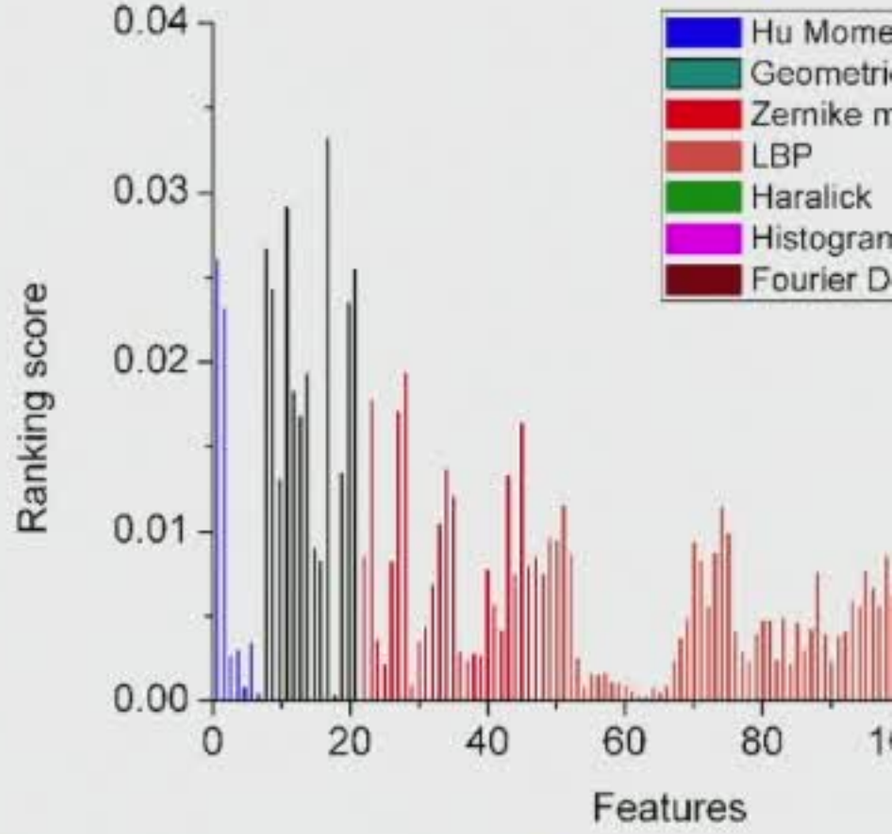
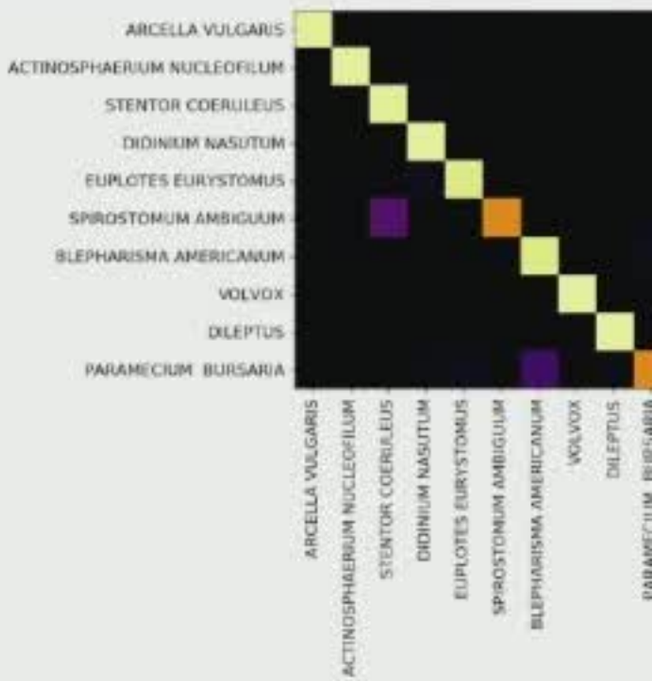
10 species separation

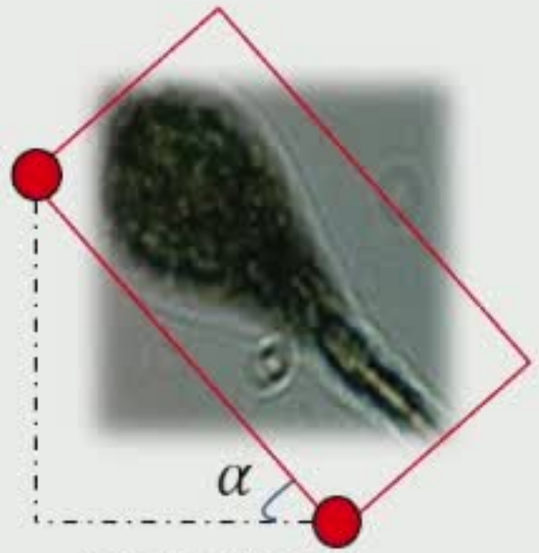


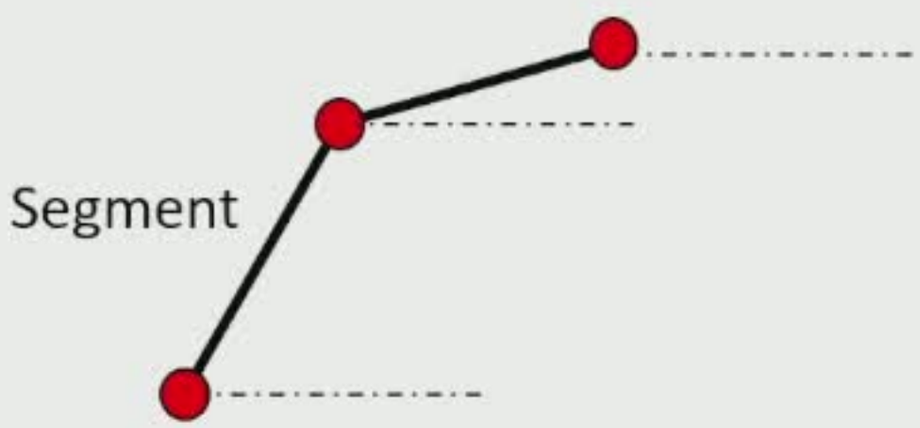




Motion-based features

- Speed
- Body angle
- Change of direction rate
- Segment length





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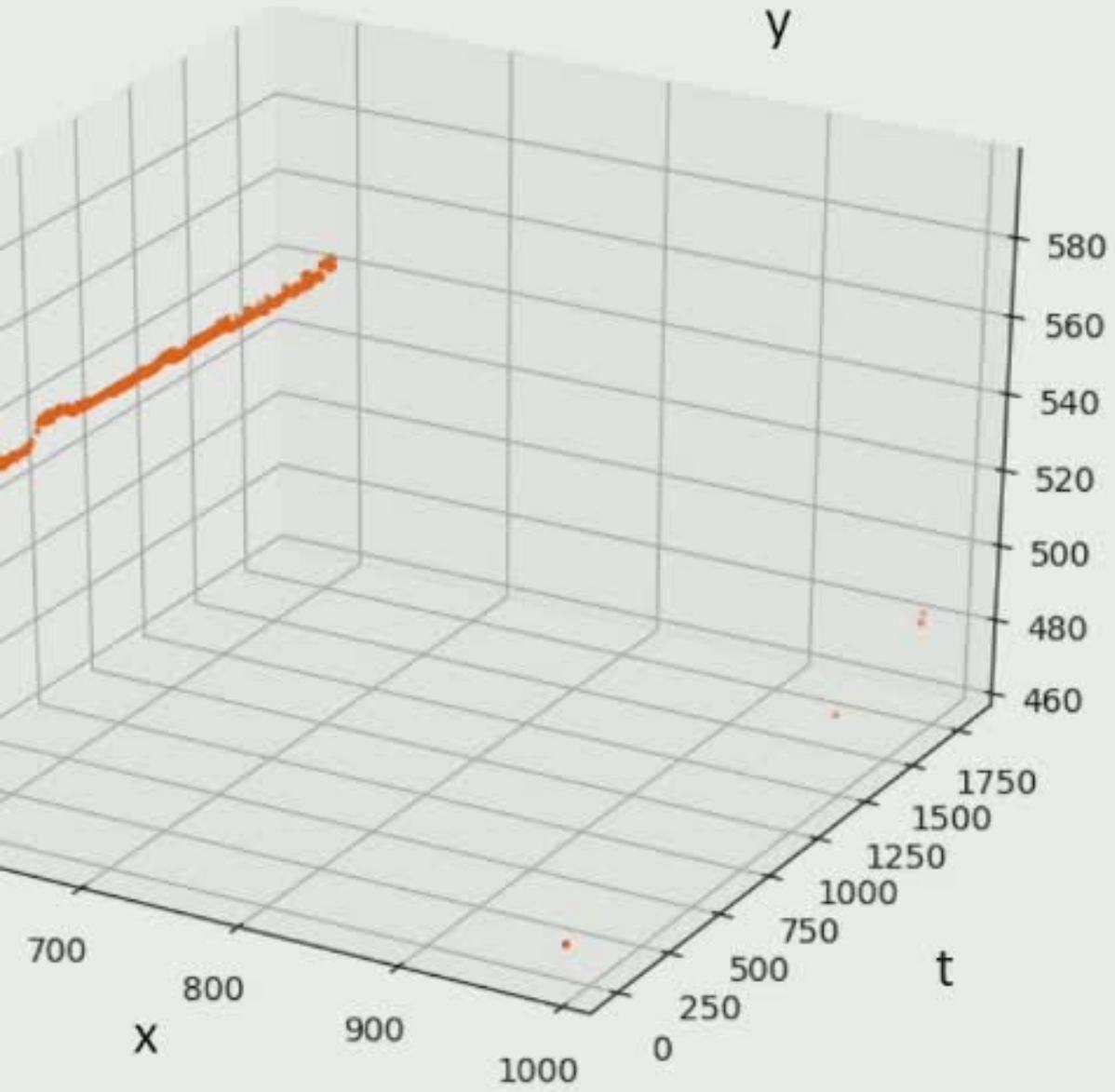
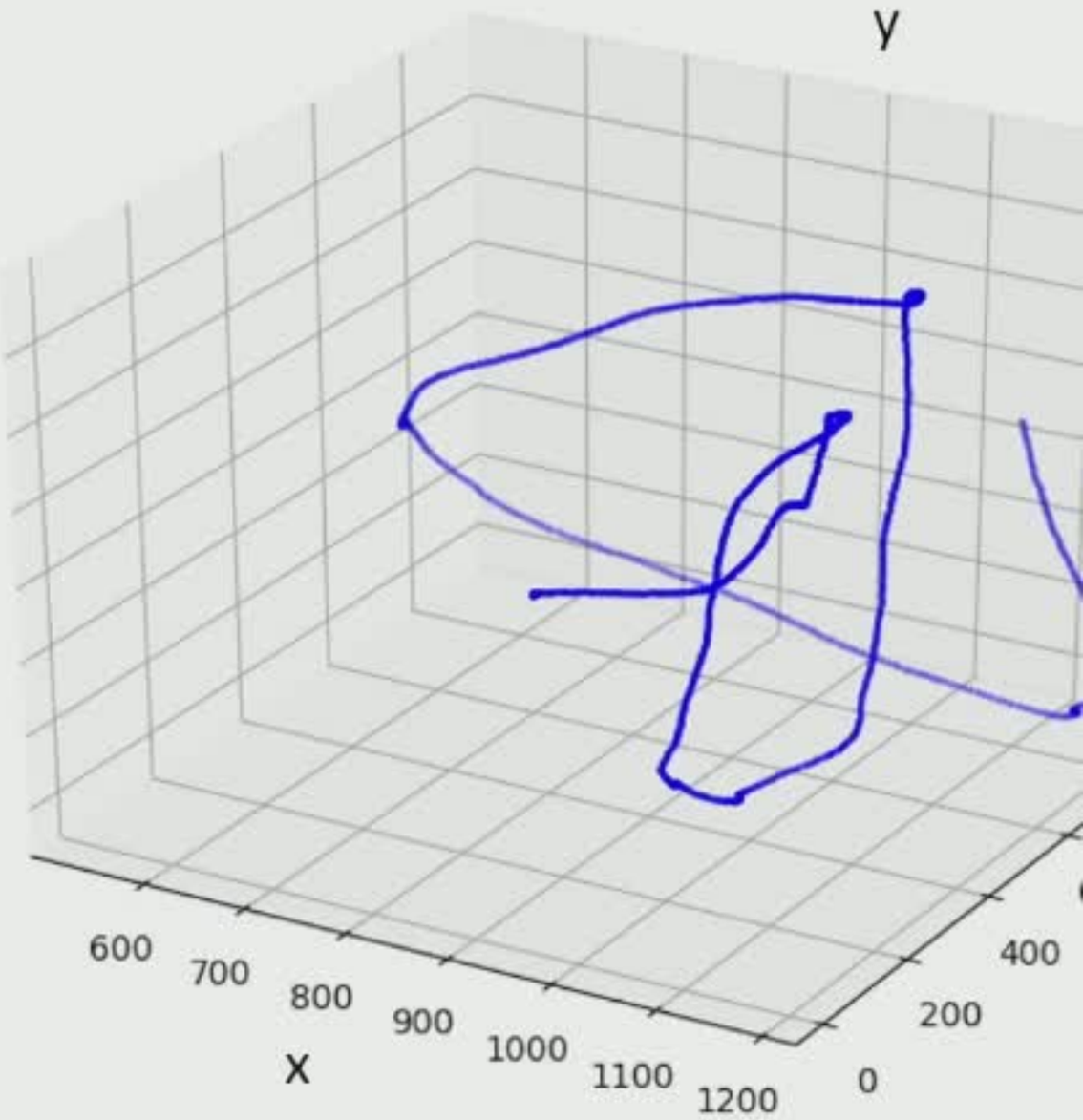
Lead Acetate versus controls

Lead acetate



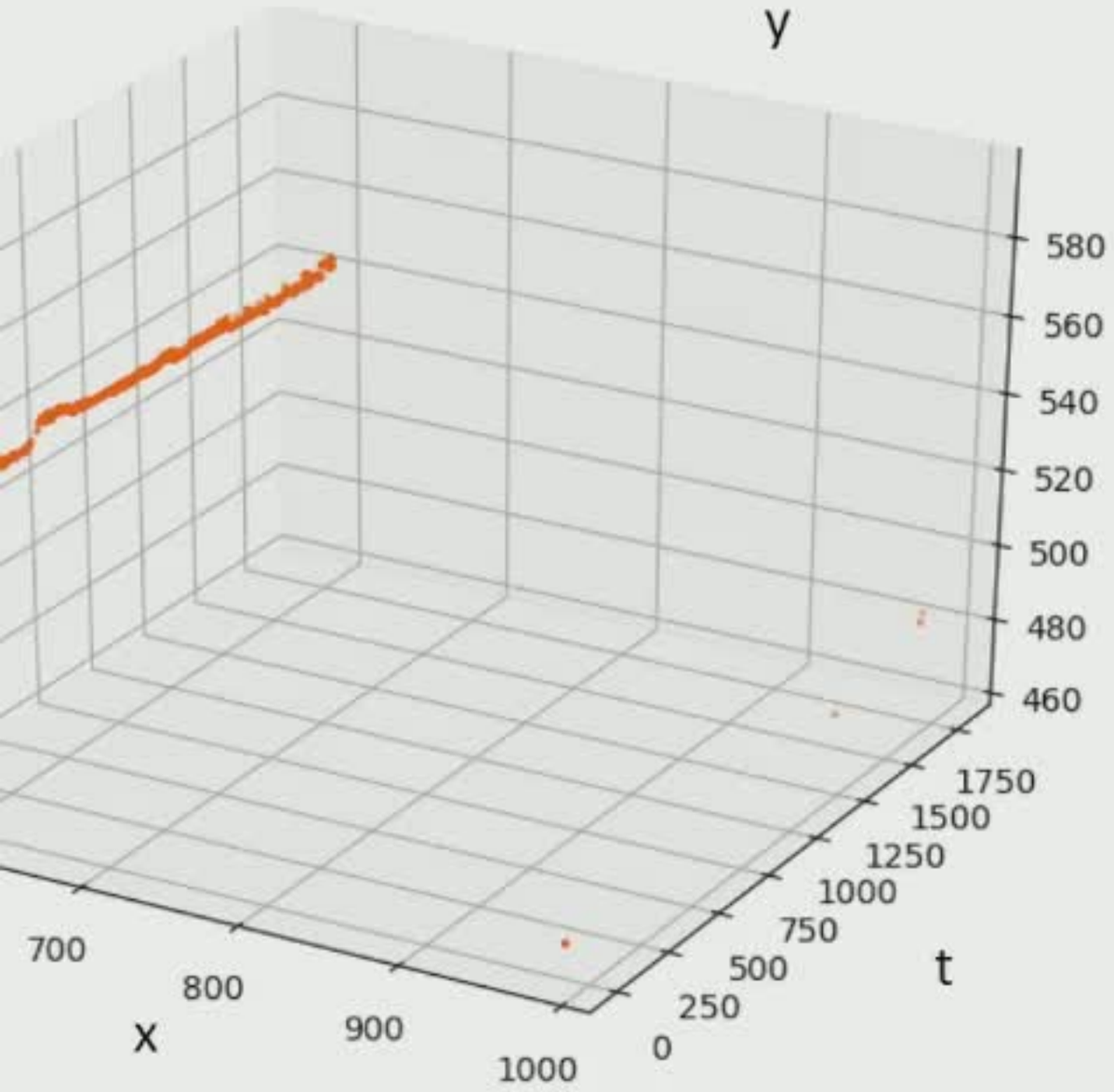
Controls



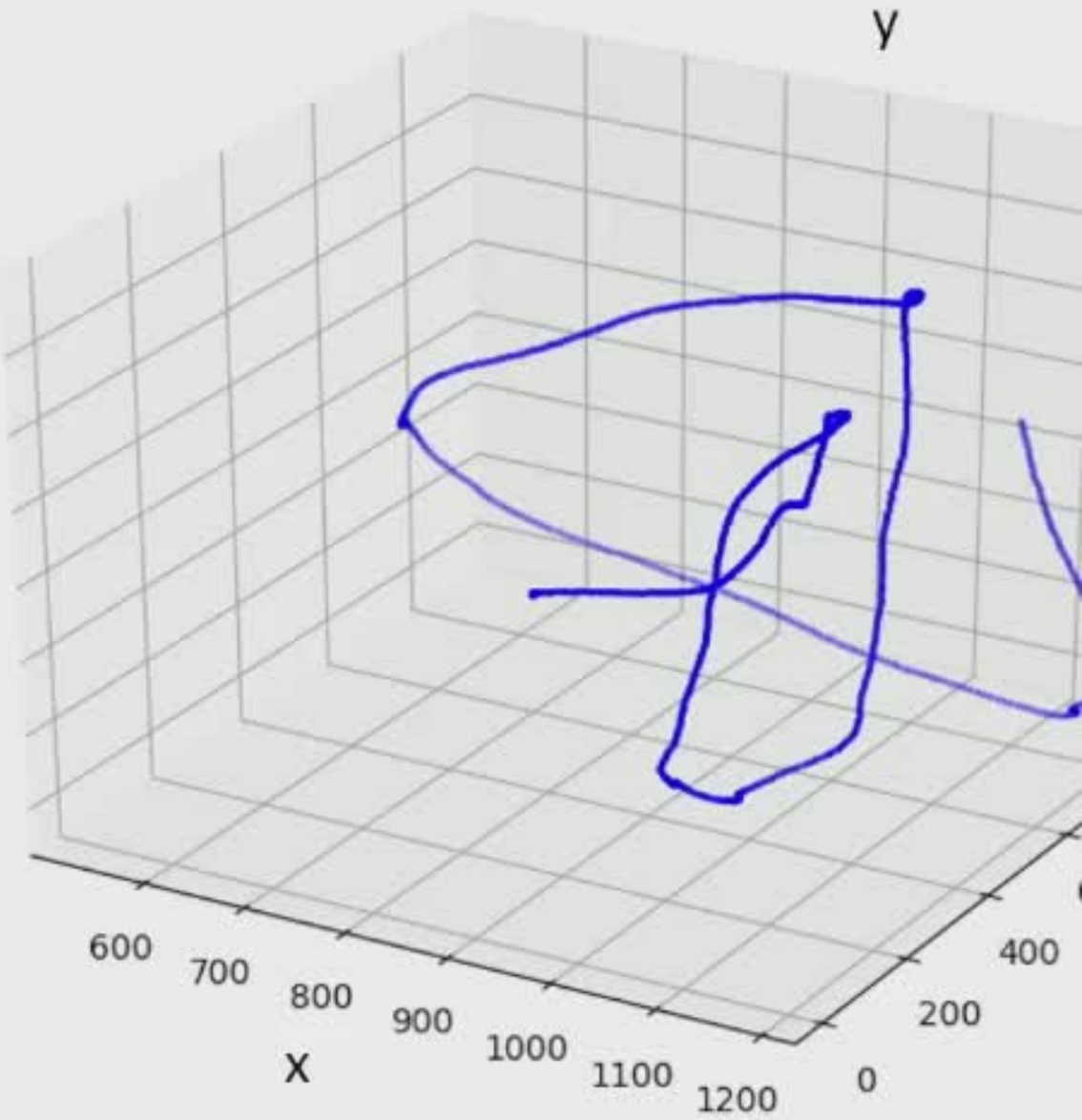
Trajectories

Lead Acetate versus controls

Lead acetate



Controls



Trajectories

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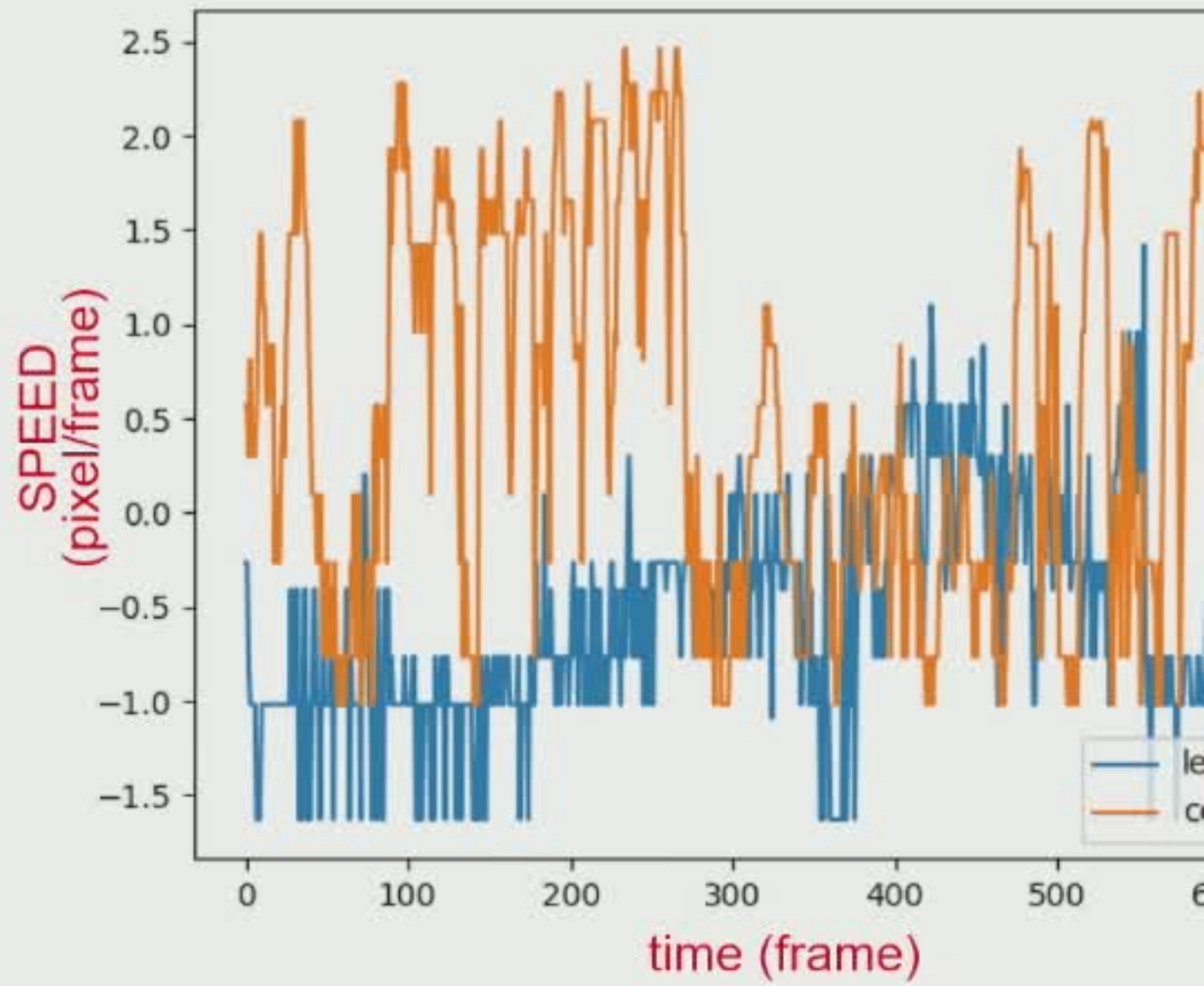
Lead Acetate versus contro

Lead Acetate dataset (n=8)

Control dataset (n=8)

Speed averaged over 10 frames



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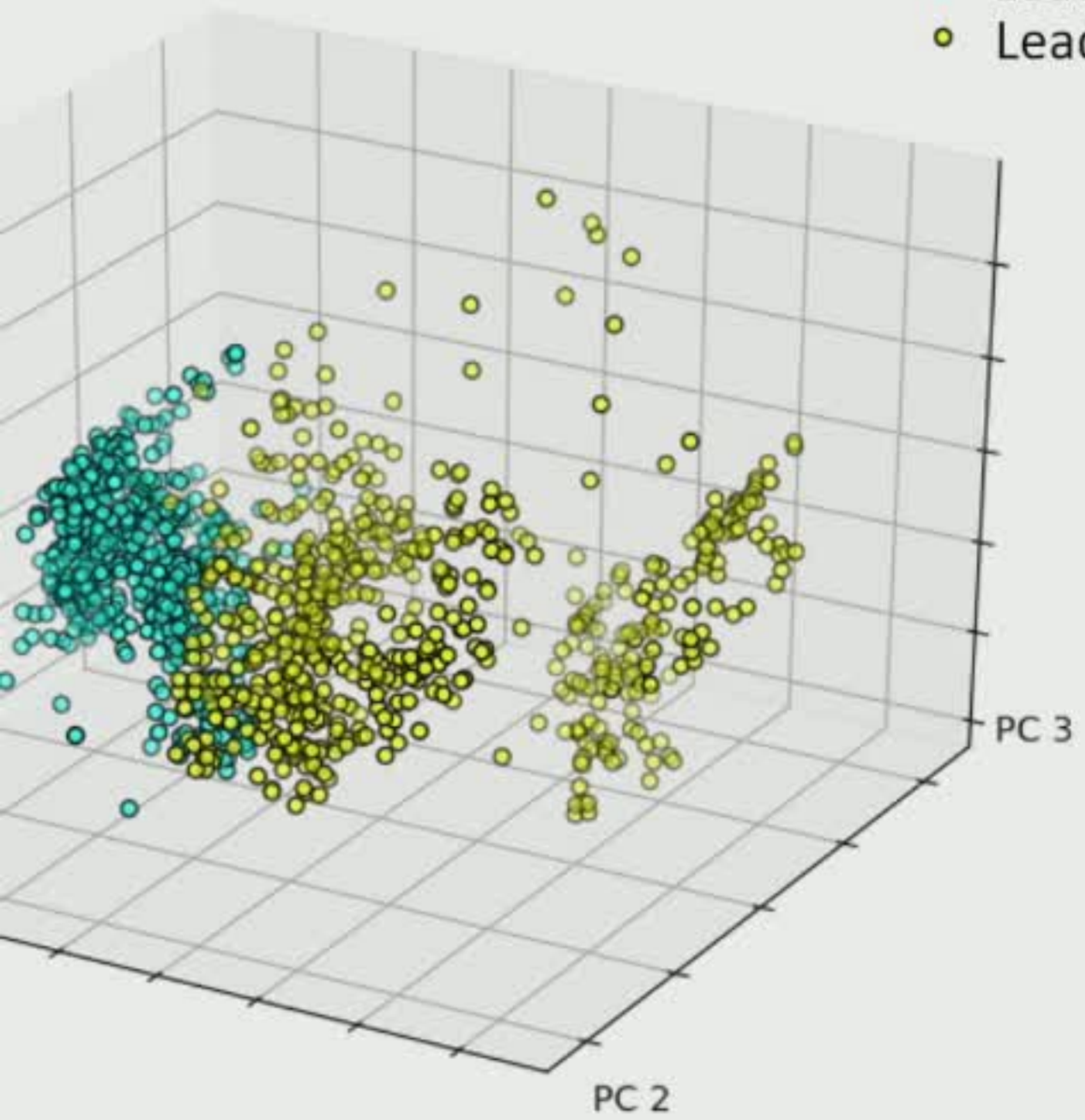
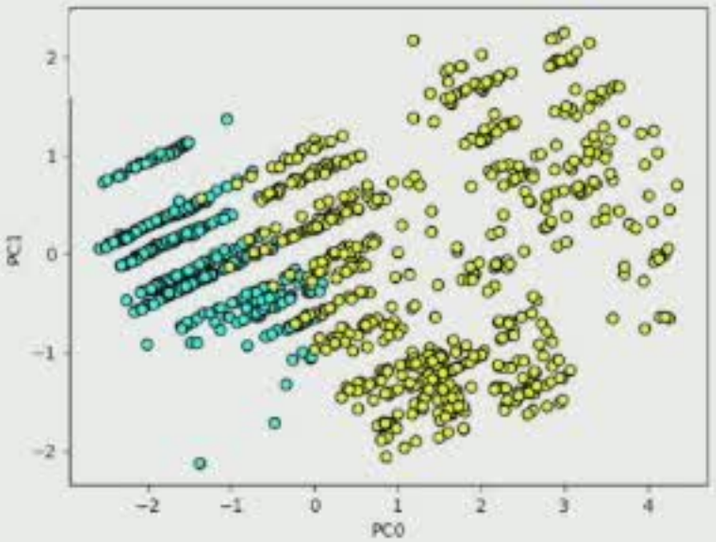
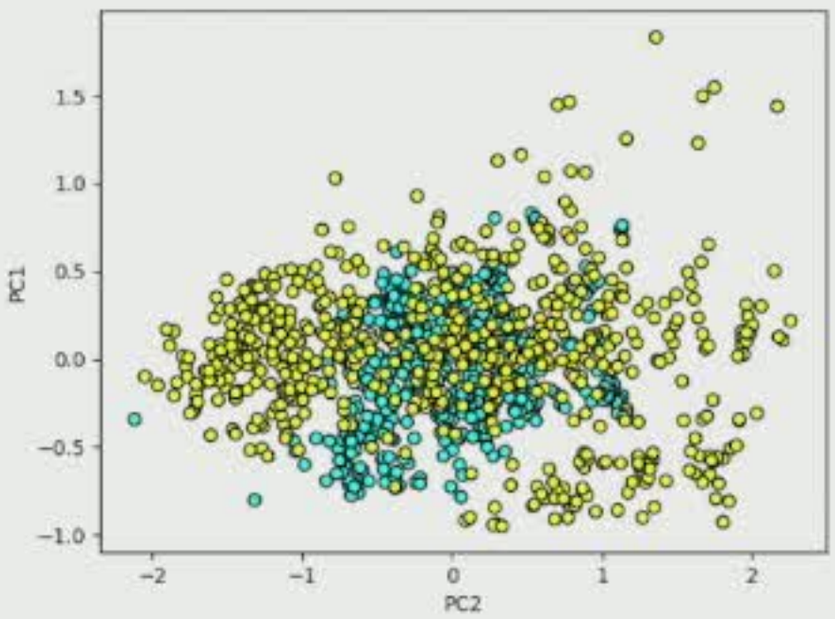
Lead Acetate versus contr

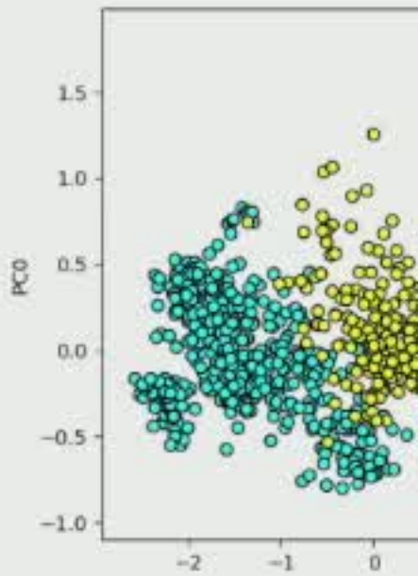
eparate stentor using the complete set of morpho-motion features?

- Lead controls
- Lead acetate



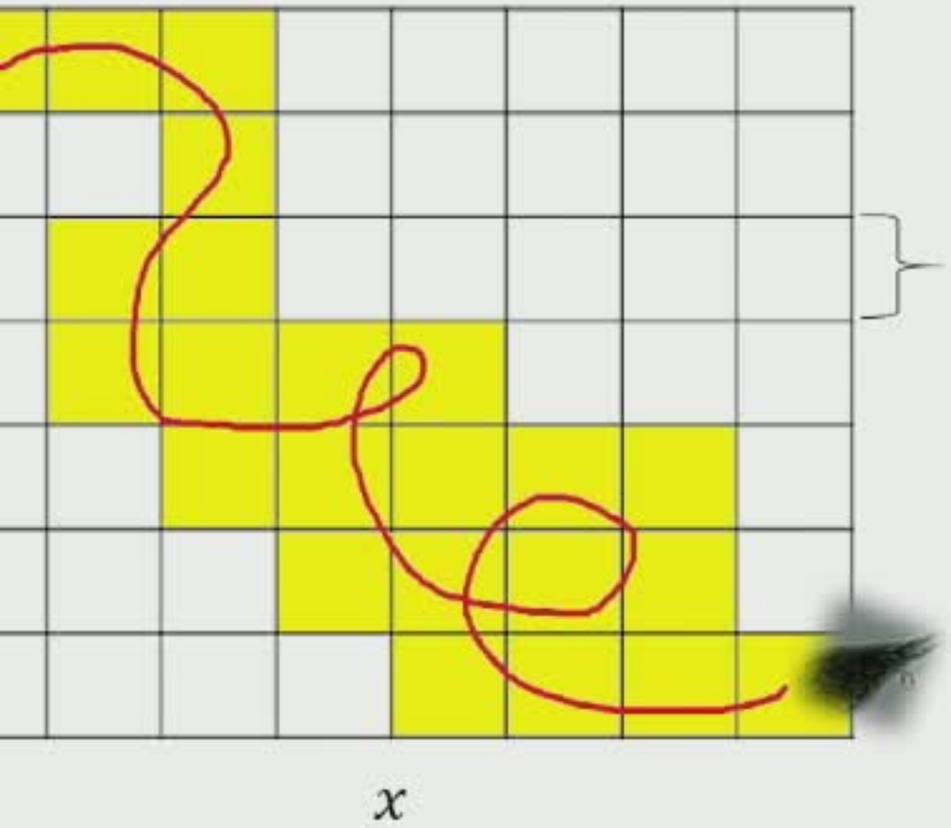


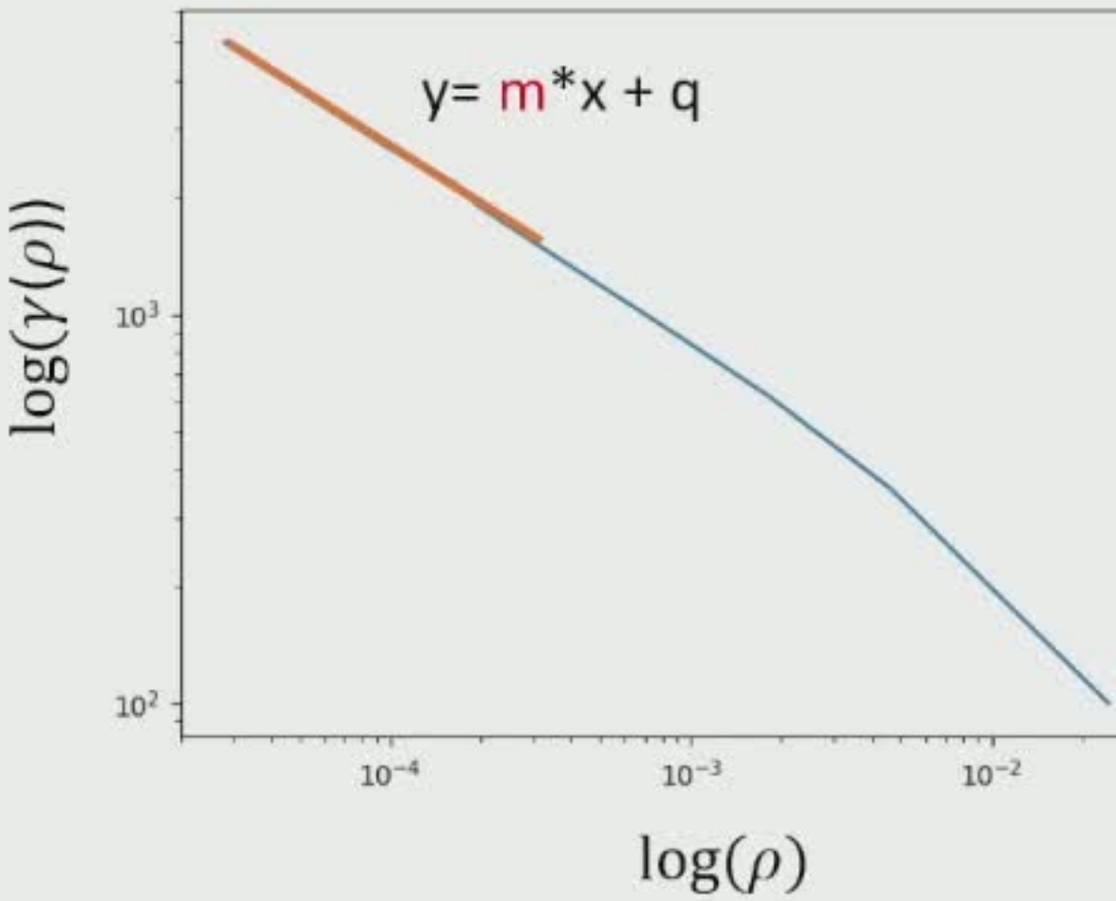




Fractal Dimension

Box Counting method





$$\gamma = \frac{23}{56} = 0.41$$

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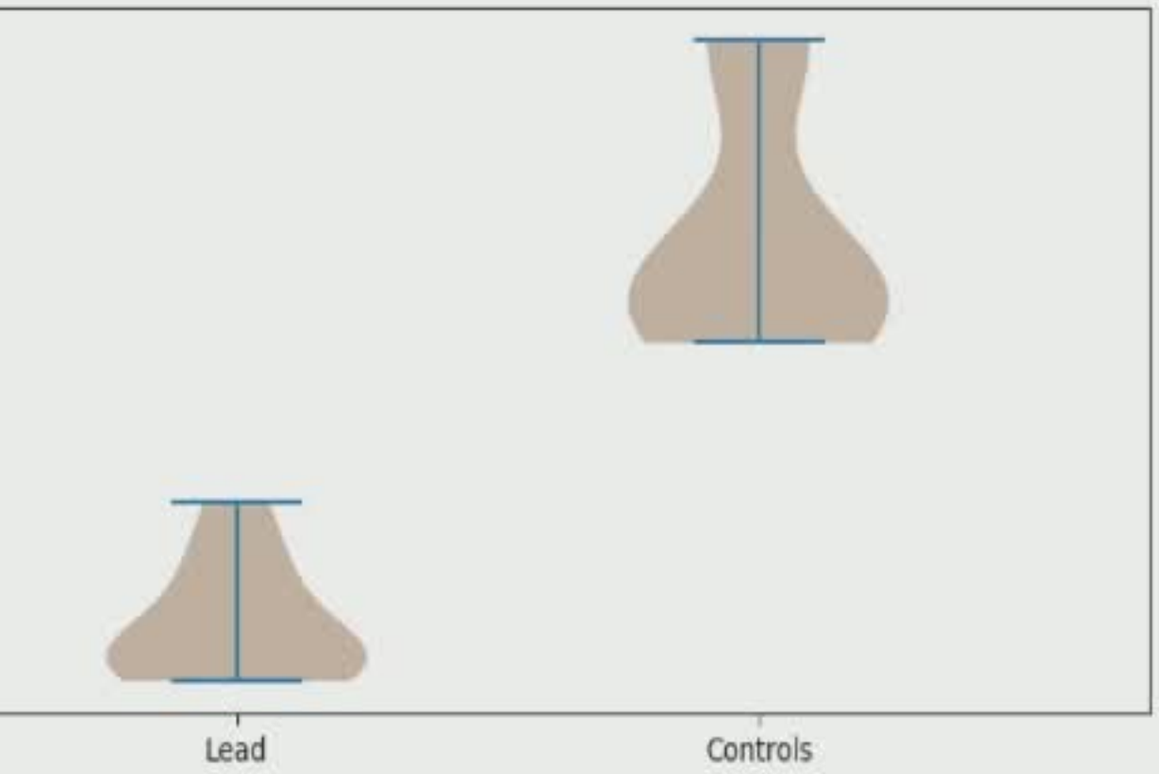
Turning rate

Change of direction rate



Segment average length

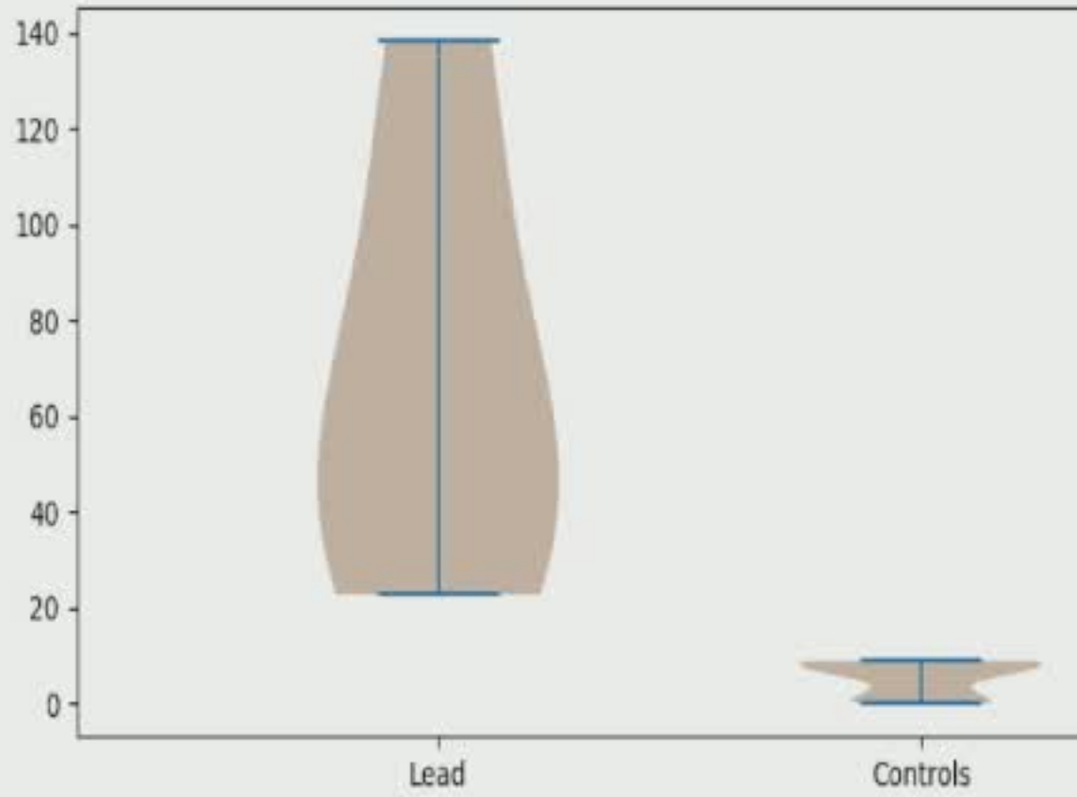


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Plate Cam results

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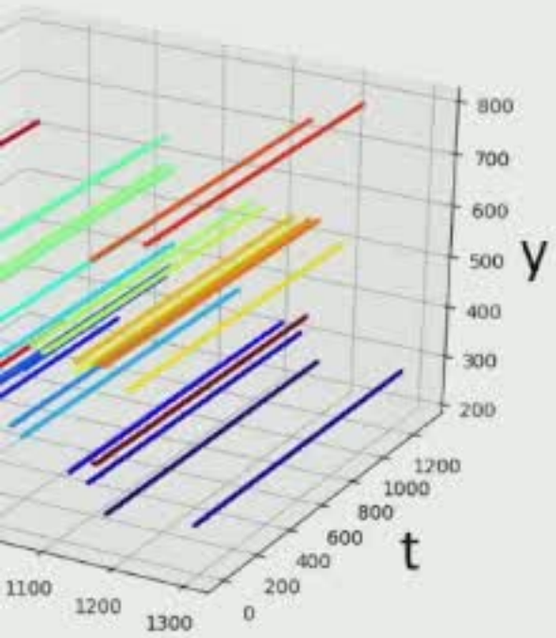
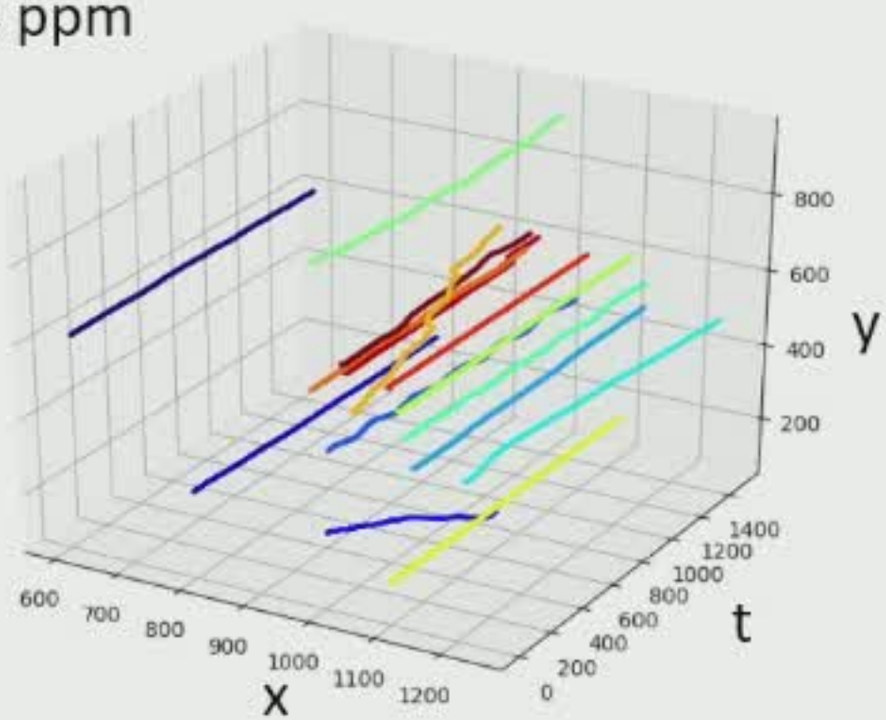
Trajectories

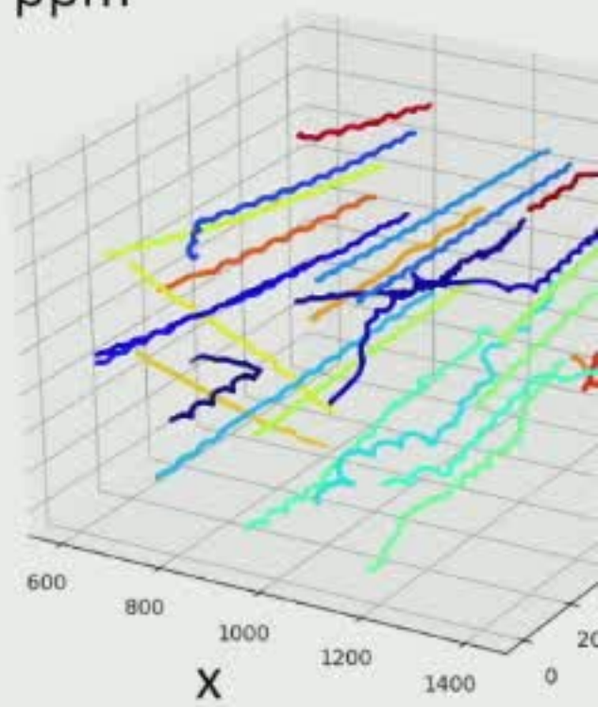
pm



121.4 ppm

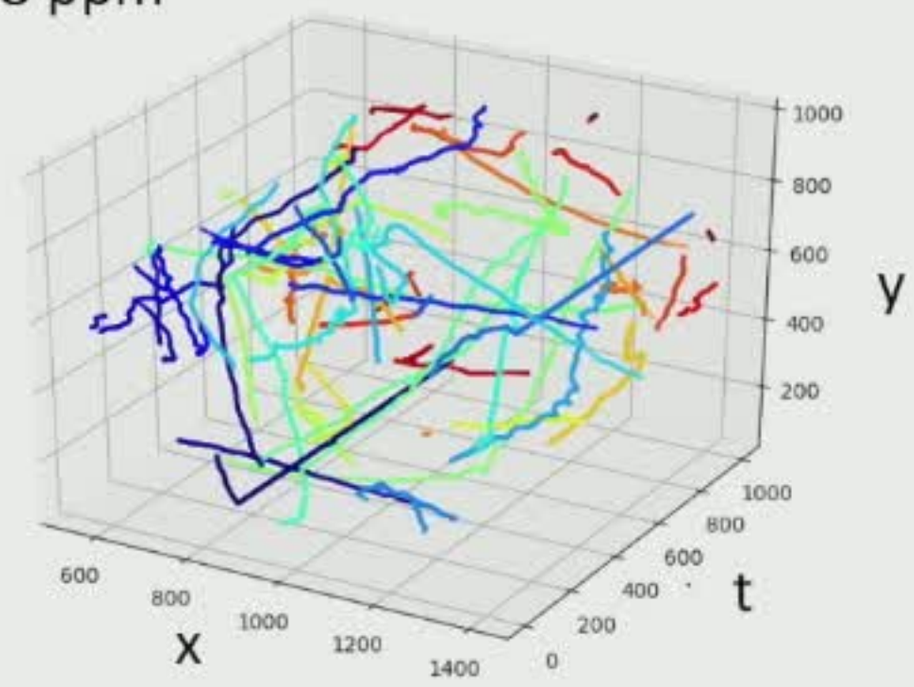


60.7 ppm

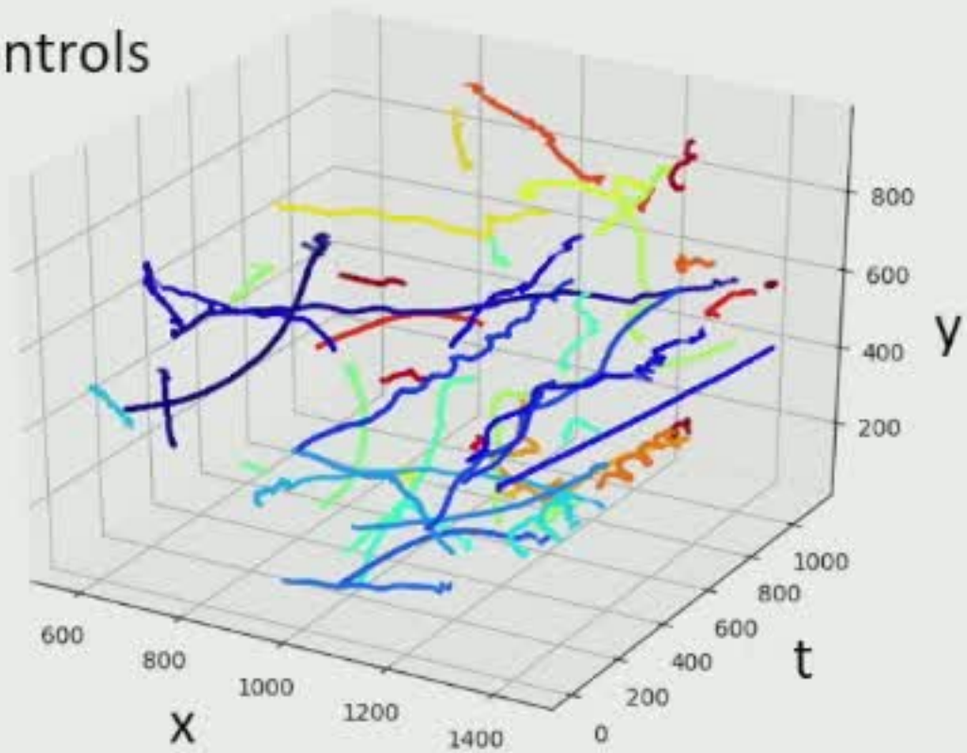


ion referred
araben

3.8 ppm



Controls



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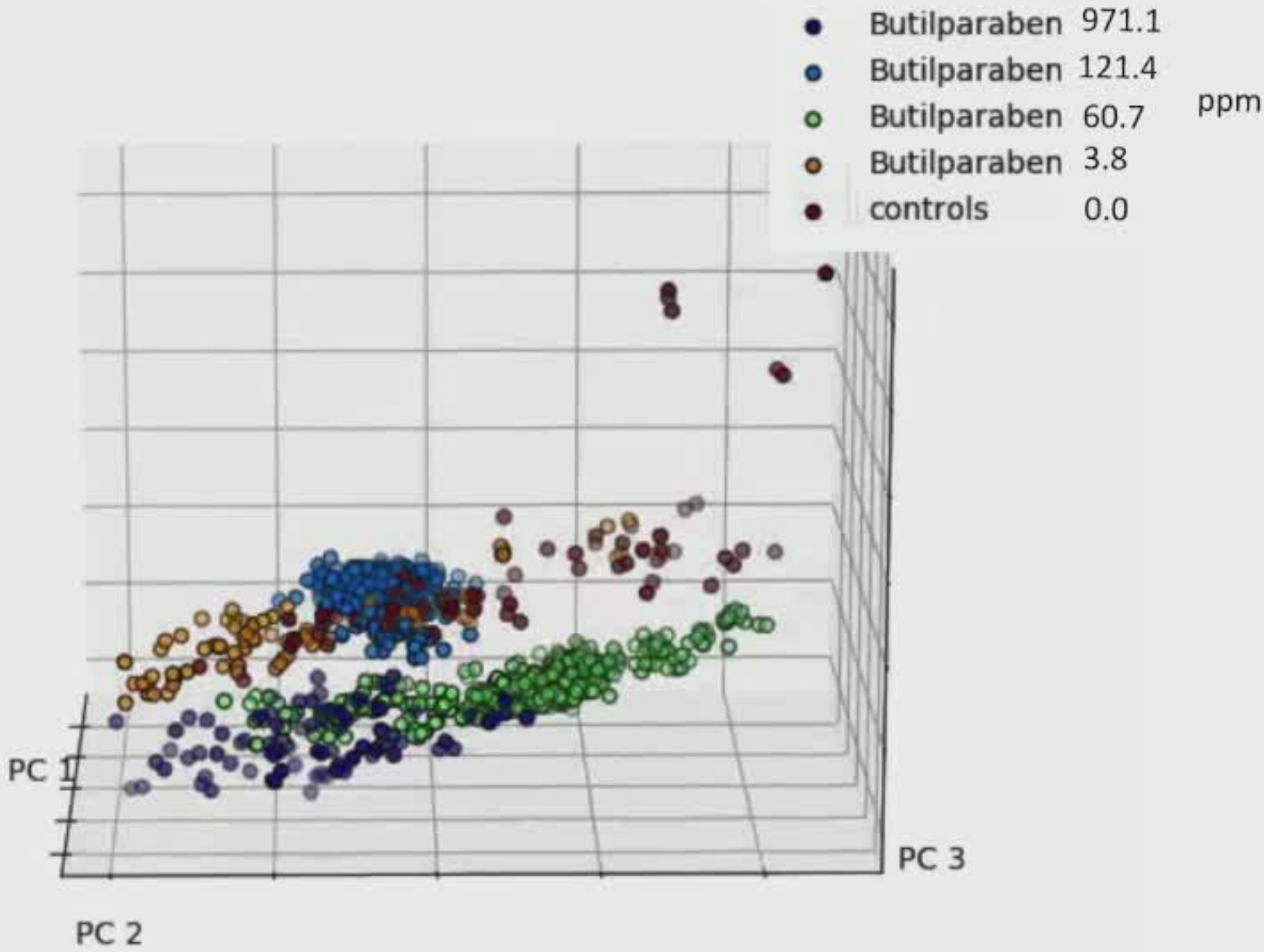
Butilparaben vs. Contro

eparate stentors using the complete set of morpho-motion features?



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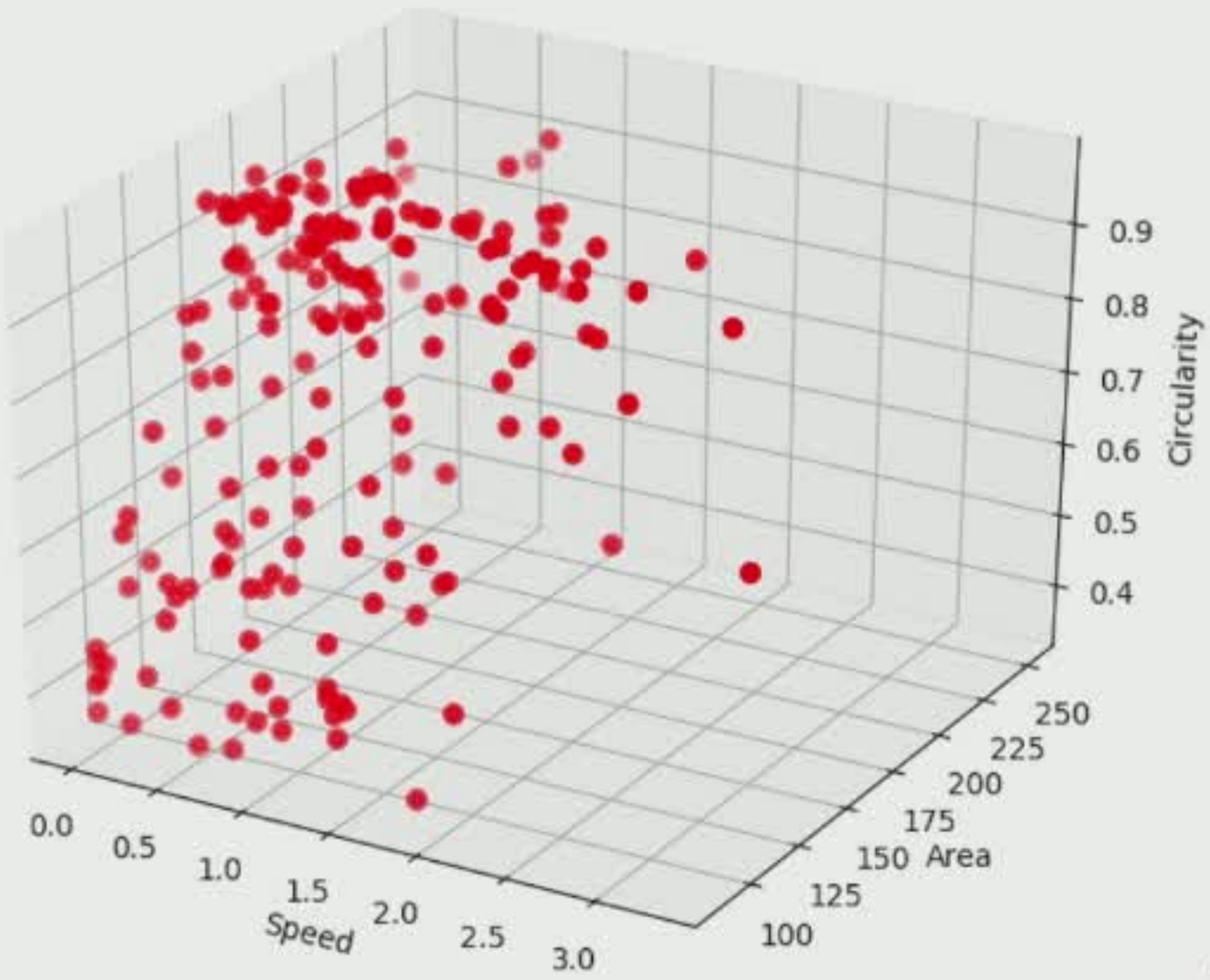
Relationship with morphology



971 ppm: Speed clustered around zero, area ar
circularity less spreaded than other conditions
(contracted shape)

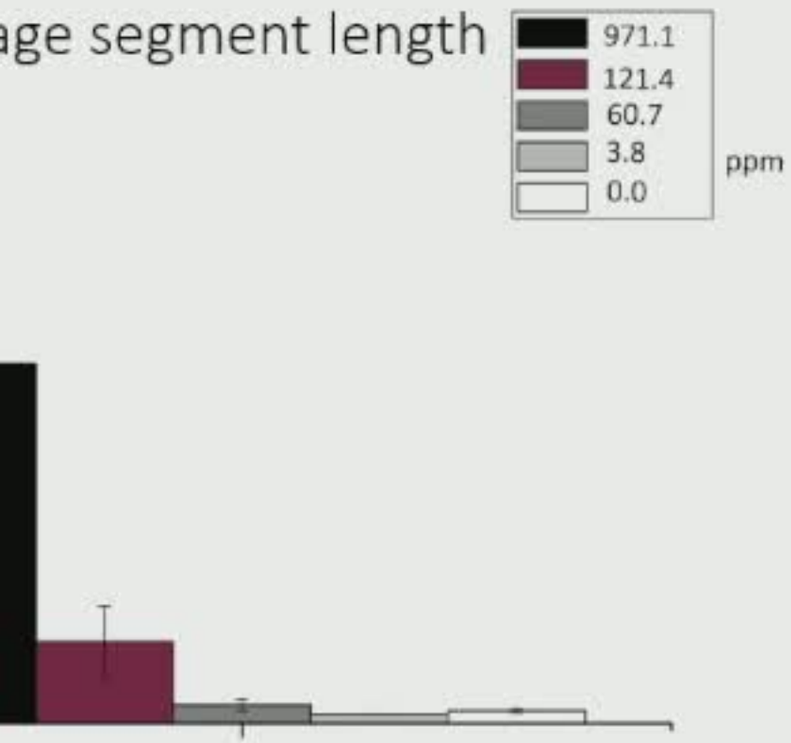
3.8 ppm: speed more spread, stentors more ac
area and circularity more spreaded

Controls: higher speed and activity, area higher
(swimming in elongated shape).

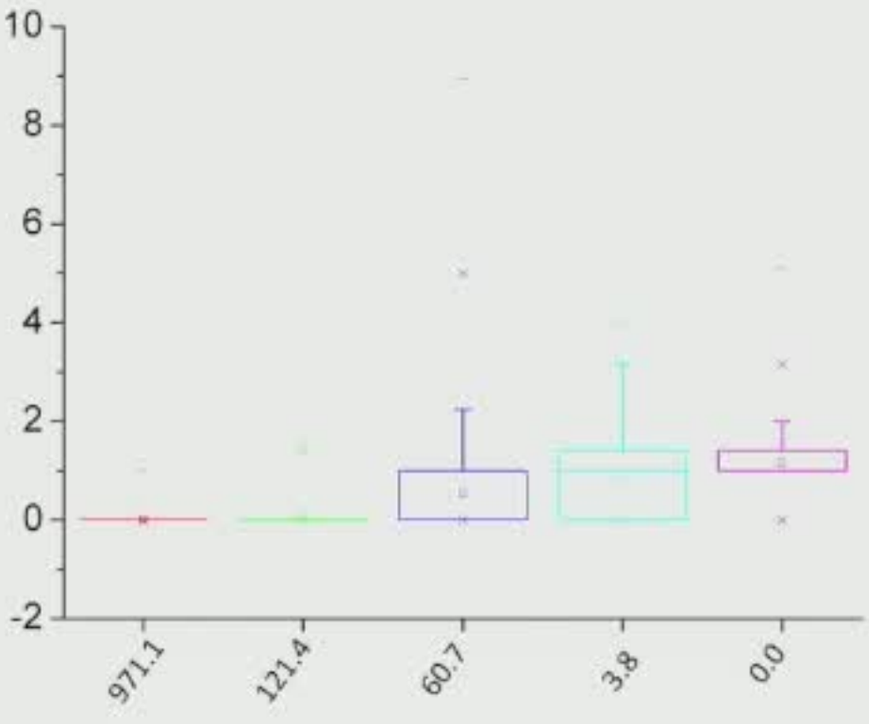
Dynamic features analy

Effect of butylparaben

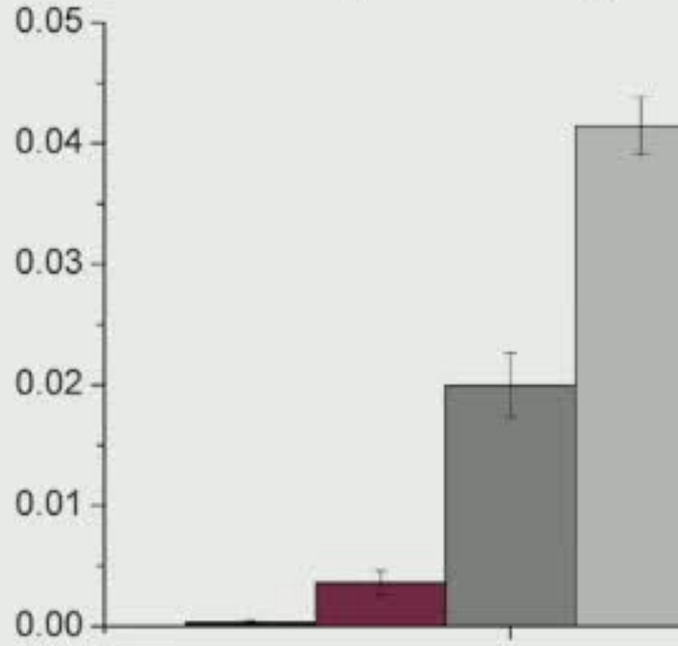
age segment length



Average speed



Average turning ra



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Conclusion

namic and morphological features allow separation between plankton in different erimental conditions

notation-free unsupervised learning of plankton clusters

maly detector approach for revealing morphological or dynamic alterations

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ure perspectives

ding a mathematical model binding
phology and dynamic to environmental
urbations

ding a chemical library in lab

olish morphological and dynamic baseline in

edding genetic features into the analysis

Acknowledgements

up

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Simone Bianco

Thomas Zimmerman

Marshall

Jennifer Fung

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