Interactive software to rapidly visualize high-resolution aquatic animal movement in 3D

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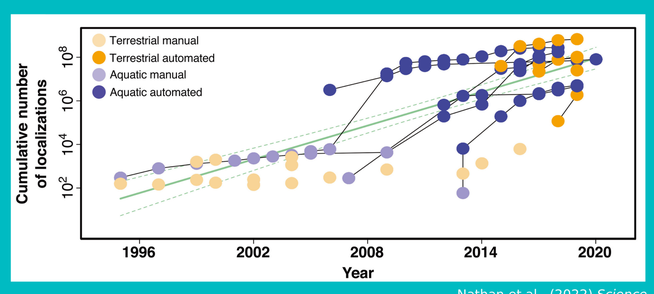
Motivation

Movement ecology is undergoing a revolution from a data-poor to a data-rich discipline, however, our ability to convert machine-sensed trajectories into meaningful observations of animal behaviour has not advanced at the same pace. New tools are needed.



Nathan et al., (2022) *Science*

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2	1158105	496798.9	6495030	21.760	2013-06-21 10:18:47
3	1158105	496800.6	6495010	25.716	2013-06-21 10:22:14
4	1158105	496803.1	6495024	24.178	2013-06-21 10:34:05
5	1158105	496798.6	6495037	21.320	2013-06-21 12:38:23
6	1158105	496814.2	6495025	28.134	2013-06-21 12:47:46
7	1158105	496849.2	6495113	24.617	2013-06-21 14:46:58
8	1158105	496821.0	6495063	21.760	2013-06-21 17:45:29
9	1158105	496811.5	6495033	25.716	2013-06-21 19:17:23
10	1158105	496803.0	6495020	24.617	2013-06-21 19:33:59
11	1158105	496812.8	6495039	24.617	2013-06-21 19:40:09
12	1127185	497016.5	6496193	19.347	2013-06-21 19:50:25
13	1158105	496815.5	6495048	23.299	2013-06-21 20:21:59
14	1158106	497005.0	6496003	25.716	2013-06-21 20:41:34
15	1158105	496812.0	6495036	25.057	2013-06-21 21:19:40
16	1158105	496805.8	6495025	25.057	2013-06-21 21:25:18
17	1158105	496808.4	6495026	25.716	2013-06-21 21:27:17
18	1158105	496812.3	6495035	25.716	2013-06-21 21:29:18
19	1158105	496804.3	6495026	24.398	2013-06-21 21:36:23
20	1158105	496808.7	6495038	23.738	2013-06-21 21:57:43
21	1158105	496802.0	6495036	22.200	2013-06-21 22:08:01
22	1158105	496810.4	6495031	25.716	2013-06-21 22:16:08
23	1158105	496790.8	6495033	18.683	2013-06-21 22:22:00

How can we quickly move from detections to understanding?

Immersive and interactive 3D tools can quickly integrate multiple data streams into a single visualization, accelerating our ability to observe patterns and make sense of the data. **We have developed open-source software using the Unity 3D Engine, for interactively visualizing 3D fine-scale fish movement.**

Available on github (alpha version)
https://github.com/Aerius01/Lake-System-Viewer

Workflow

The software streams data from a postgresql database, which can be hosted locally or remotely. Minimum requirements for the database are fish metadata, position and meshmap (i.e. bathymetry) tables. The first step after downloading the software is to establish a database and setup the tables with the structure the software expects. Tables with additional data such as weather data, thermocline information, or macrophyte maps can also be added.

Positions

(coordinates scaled to meshmap dimensions)

	id	timestamp	x	y	z
1	1113602	2014-11-20 08:56:19	186.7752	282.8133	-8.792
2	1113602	2014-11-20 09:41:18	184.4991	295.5873	-23.518
3	1113602	2014-11-20 10:14:59	184.7195	295.4758	-23.518
4	1113602	2014-11-20 11:08:30	184.6847	295.4981	-23.738
5	1113602	2014-11-20 12:51:43	184.4875	295.5873	-23.738
6	1113602	2014-11-20 13:11:58	184.4991	295.5873	-23.738

Fish metadata

	id	species	tl
1	1113894	1	30
2	1113895	1	44
3	1113899	1	57
4	1113900	1	54
5	1113901	1	32
6	1113902	1	64

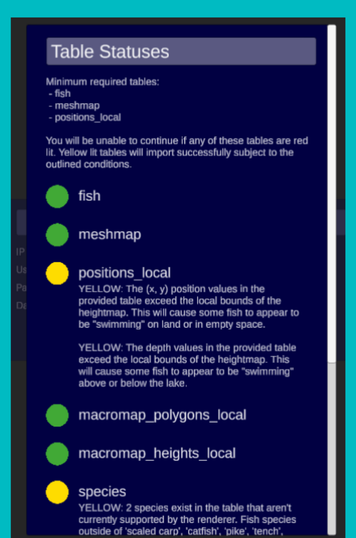
Meshmap

0	-30	-30	-29	-29	-29
0	0	0	0	0	0
0	0	0			
0	0	0			
0	0	0			
0	0	0			

PostgreSQL

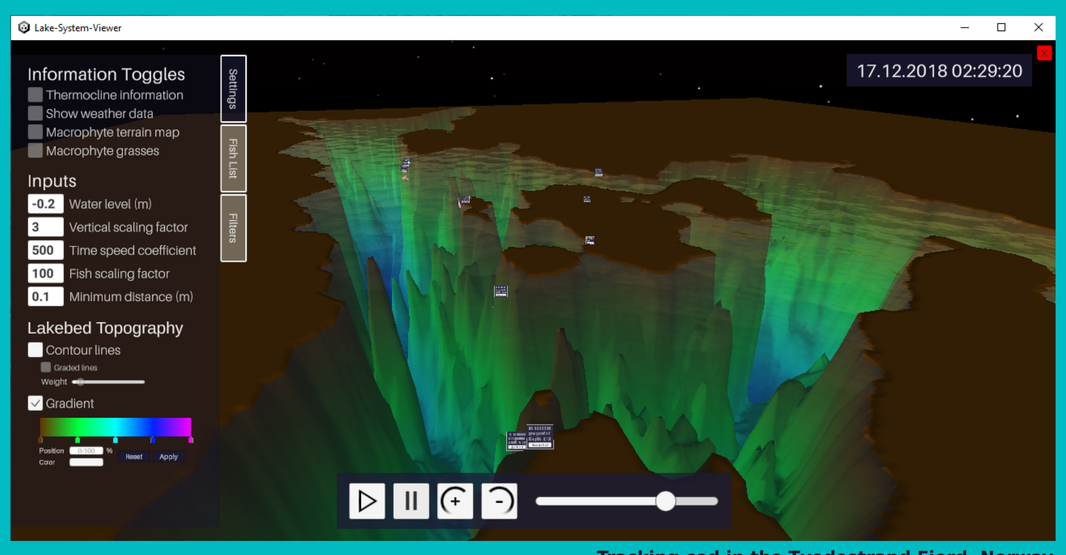
The database connection can be specified immediately after opening the software. Before starting the visualization, the connection is tested and the structure of the tables is verified. After passing the verification tests, the interactive visualization can start.

Example database connection



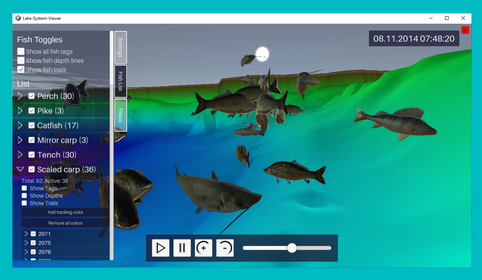
Screenshot after table verification

Features

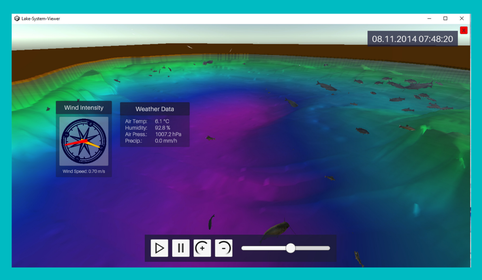


Tracking cod in the Tvedestrand Fjord, Norway

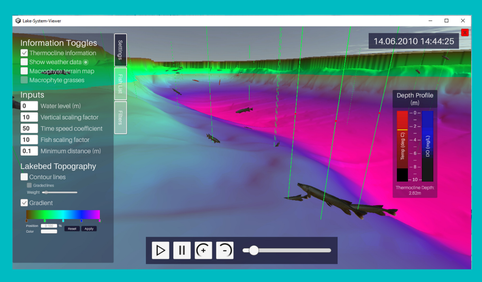
Multispecies



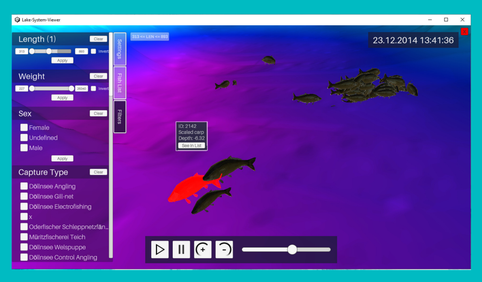
Weather data



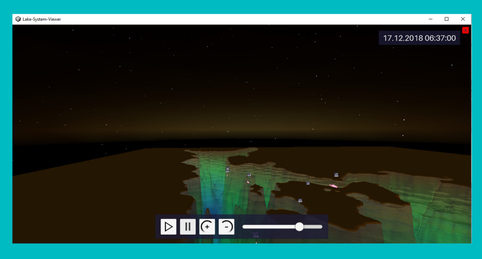
Thermocline

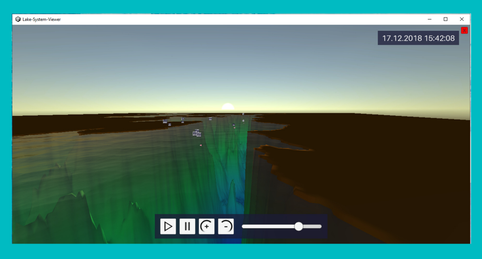


Filters & Highlights



Sunrise & sunset





Discussion

This software is open-source and we hope for community contributions and feedback. It is an early version, with bugs to find and many improvements to be made. We aim to make it as general and easy to use as possible. It is best suited for fine-scale tracking datasets, but it is also appropriate for coarse-scale tracking, for example along coastlines.

The software could be an effective tool for outreach and science communication given the interactive and visual nature

The software also has potential to contribute towards ongoing efforts to create digital twins, particularly contributing towards the biological components of digital twins.

Most importantly, we hope the sofware can be used to efficiently gather insights into existing and future telemetry datasets and we hope it will help to create new hypotheses related to fish behavioural ecology.

Acknowledgements

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