DIGITAL TWINS OF THE OCEAN: 2D/3D/4D MICROPARTICLE FLOW VISUALISATIONS

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Within the context of the Iliad project, the authors present early design mock-ups and resulting technical challenges for a 2D/3D/4D geo-data visualisation application focused on microparticle flows. The Iliad – Digital Twins of the Ocean project (EU Horizon 2020) aims to develop a 'system of systems' for creating cutting-edge digital twins of specific sea and ocean areas for diverse purposes related to their sustainable use and protection. One of the Iliad pilots addresses the topic of water quality monitoring by creating an application offering dynamic 2D and 3D visualisations of specifically identified microparticles, initially observed by buoys/sensors deployed at specific locations and whose subsequent flows are modelled by separate software. The main upcoming technical challenges concern the data-driven approach, where the application's input data is completely obtained through external API-based services offering (near) real-time observed data from buoys/sensors and simulated data emanating from particle transport models.

Keywords: *ocean digital twin, real-time sensor data, 2D & 3D data visualisation, time series data visualisation*

1. Introduction

The Iliad – Digital Twins of the Ocean project (EU Horizon 2020) aims to develop a system of systems for creating cutting-edge digital twins of specific sea and ocean areas for diverse purposes, notably related to their sustainable use and protection. The project will fuse a large volume of data in a semantically rich and data-agnostic approach to enable simultaneous communication with real-world systems and models. Ontologies and a standard style-layered descriptor will facilitate semantic information and intuitive discovery of underlying information and knowledge to provide a seamless experience. The combination of geovisualisation, immersive visualisation and virtual or augmented reality allows users to explore, synthesize, present, and analyse the underlying geospatial data in an interactive manner. To develop and demonstrate its 'system of systems', the Iliad project relies strongly on 20+ pilots, i.e., actual ocean digital twin instances at specific areas for specific purposes [1].

One of the Iliad pilots addresses the topic of water quality monitoring by creating an application offering dynamic 2D and 3D visualisations of specifically identified microparticles, initially observed by buoys/sensors deployed at specific locations and whose subsequent flows are modelled by separate software. Different microparticles might be monitored through such an application, notably micro-organic or microplastics. Other so-called transport models might subsequently be used to extrapolate how the observed microparticles flow in and beyond the sea area around the buoy/sensor over the next hours, days or weeks. The end-user should be able to view this in both 2D (top-down) and 3D, and in both cases with time controls (the '4D' aspect). In the end, the application should also offer an alerting service, so end-users can also be notified of certain (concentration levels of) microparticles when they are observed by the buoy/sensor and base their use of the application on such an alert or notification.

Two of the Iliad partners involved in this pilot are SINTEF Ocean and NTNU. Based in Trondheim, Norway, they developed and deployed OceanLab, which includes a research buoy for essential ocean variables, a microparticle observing camera, a machine-learning-based particle recognition algorithm, and an infrastructure for (near) real-time data retrieval.

Breda University of Applied Sciences (BUas) supports this pilot by leading the development of new visualisation software. Based in Breda, the Netherlands, BUas' Academy of AI, Games Media offers internationally highly regarded educational and research programmes with innovative technologies (particularly game and media). Over the past seven years, several BUas' RD staff have developed more and more expertise in using geo-data from Geographical Information Systems (GIS) with game engines, notably Unity and Unreal, to create engaging, user-friendly, multi-user systems for 2D, 3D and 4D marine/maritime planning, simulations and visualisations. With this expertise and continued interest, BUas will develop a key system for interactive 2D/3D/4D microparticle visualisations within the Iliad 'system of systems' for any other interested pilot or future digital twin of the ocean.

In this extended abstract, the authors explain through early mock-ups the design they are considering for the interactive 2D/3D/4D microparticle visualisation application and the resulting technical challenges they expect to face. The latter is also the result of the data-driven approach taken in developing this application, which is also further explained.

2. First Interface Design Mock-ups

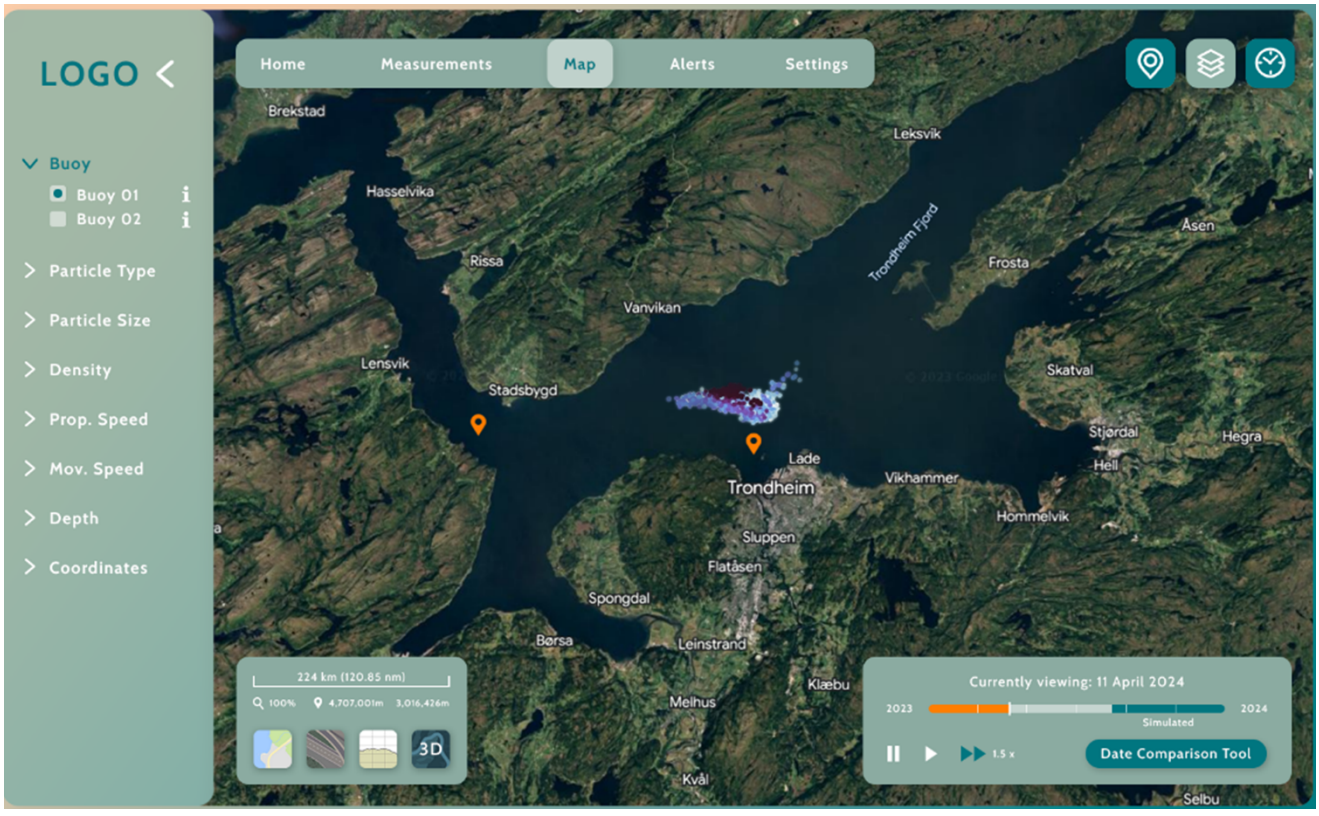

Figure 1: Mock-up of 2D/map-based microparticle visualisation interface, with time controls.

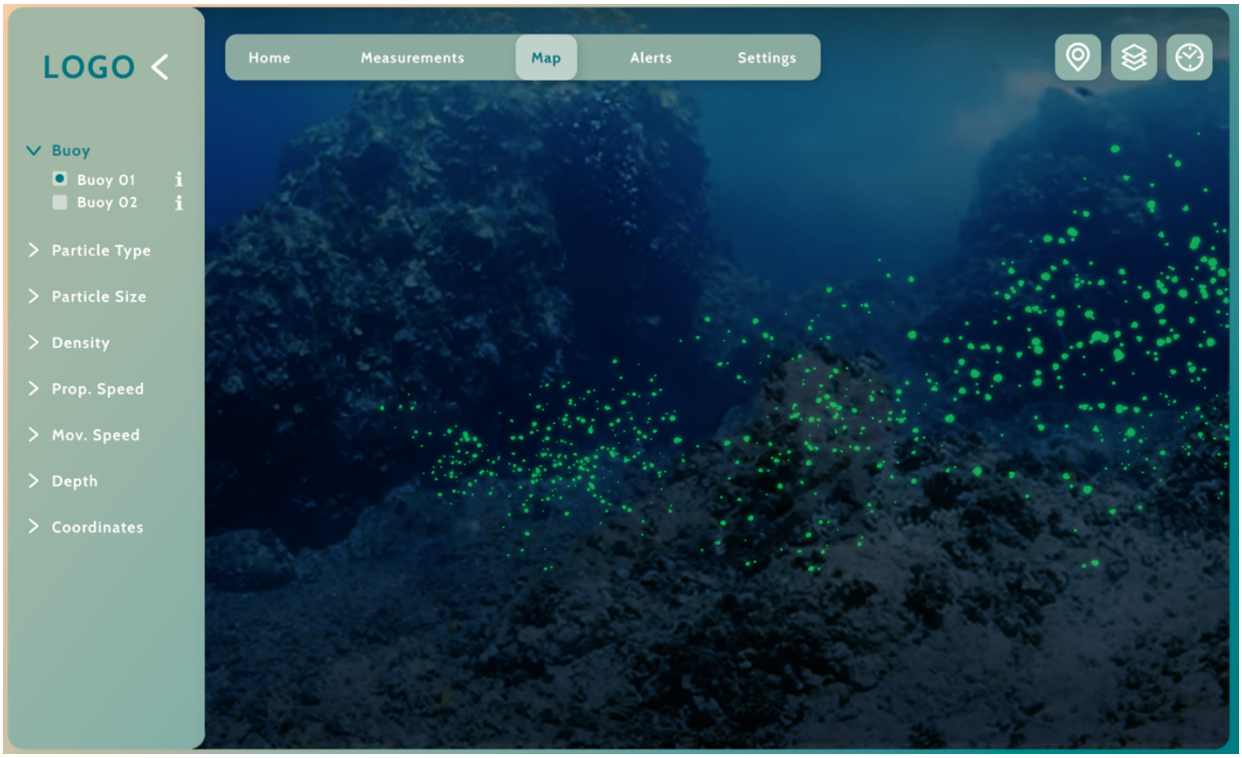

Figure 2: Mock-up of 3D microparticle visualisation interface.

3. Technical Challenges

The main objective here is to create a new bit of software that can take any (near) real-time observed and modelled flow of microparticles delivered through multiple services' APIs and offer 2D and 3D visualisations, also dynamically throughout an appropriate period (hence the 4D). Ideally, the trigger for using the application is not the users themselves but also the application alerting those users of certain types and concentrations of microparticles. Given our expertise with game engines and our wish to provide an interface with which end-users can quickly and seamlessly switch between 2D and 3D visualisations of high quality, we will develop this as a native Windows and macOS app using the Unity 3D game engine. Given this main objective and taking an agile/iterative approach to the development of this system, we are currently working on the following main technical challenges:

- Identifying appropriate 3D time-series-based geo-data standards and protocols serving as input data for this application, usable for both (near) real-time observed data emanating from buoys/sensors and simulated data obtained from particle transport models.
- Ensuring the input data provides complete and correct metadata of again appropriate standards so that the application has absolutely nothing hard-coded and can present the input data in a way that the user can fully understand it.
- Actually getting the application to on-the-fly obtain the input data in 'bursts' or streams from different sources, i.e., the (near) real-time observed sensor data and the output data of the particle transport model.
- Implementing key modular functionalities (particularly the alerting functionality) of the user experience as separate applications or services to add as another system within Iliad's 'system of systems'.
- Integrating the separate services or components seamlessly and with limited to no lag for an optimal end-user experience.

REFERENCES

1. , (2023), *Iliad - Digital Twins of the Ocean*. `https://www.ocean-twin.eu/,lastaccessed31May`.