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A Cosmic View of Life on Earth

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A Cosmic View of Life on Earth

Visualizing Biology Through an Astronomical Lens

What if the tools used to explore galaxies could also help us understand life on Earth?

Across scientific disciplines, researchers face a common challenge: how to visualise increasingly large and complex datasets. Astronomers routinely analyse massive catalogs of stars and galaxies to uncover the structure of the universe. Biologists, in parallel, work with extensive datasets describing a variety of details about species. Although these fields investigate very different systems, they share a fundamental problem: how to transform multidimensional data into forms that reveal understandable patterns.

The interdisciplinary article **"A Cosmic View of Life on Earth: Hierarchical Visualization of Biological Data Using Astronomical Software,"** [1] developed by **ARISE** partner Linköping University, explores a novel response to this challenge. By adapting **OpenSpace,** an open-source visualisation platform created for astrophysics, researchers have developed a way to represent biological data within an interactive, spatial environment. The piece is based on the work of two master thesis projects at Linköping University, where the students went to the American Museum of Natural History in New York, USA. From there, they also collaborated with researchers from Basel, Switzerland.

Techniques used to map the universe are repurposed to visualize evolutionary relationships, biodiversity patterns, and ecological data.

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The result is a framework that allows users to explore biological information dynamically, offering new possibilities for research, education, and scientific communication.

Harmonizing Biological Data Through Dimensionality-Reduction Techniques

Biological datasets are inherently multidimensional. Information about organisms may include genetic sequences, morphological traits, ecological characteristics, and geographic distributions. Each of these dimensions contributes to understanding how species evolve and interact, but their complexity can make the data difficult to interpret.

To address this challenge, the project employs **dimensionality-reduction techniques**, a method that transforms high-dimensional datasets into lower-dimensional representations while preserving their most meaningful relationships. This technique translates complex biological information into spatial coordinates that can be visualized in two or three dimensions.

In practice, this means that organisms or species can be represented as points within a spatial structure where proximity reflects similarity or evolutionary relatedness. Clusters may correspond to taxonomic groups or shared traits, while larger spatial patterns can highlight broader evolutionary structures within the data.

Approaches like this are widely used in astronomy to organize vast catalogs of celestial objects. By applying similar methods to biological datasets, researchers can create interactive “maps” of biodiversity that make large-scale relationships easier to explore and interpret.

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Immersive Environments: From Flat Screens to Planetarium Domes

A key feature of the project is its use of immersive visualization environments made possible by the OpenSpace platform. Originally developed to support astronomical visualization and outreach, OpenSpace enables interactive exploration of complex spatial datasets across a wide range of display systems.

The platform supports conventional desktop screens as well as large-scale projecting environments such as tiled displays and **full-dome planetarium projections.** This flexibility allows the same dataset to be explored in different contexts, from research analysis to educational presentations.

In large immersive environments such as planetariums, this approach offers particularly compelling opportunities for science communication. Representations originally designed for astronomical journeys can instead guide audiences through the diversity of life on Earth, transforming abstract biological data into an accessible experience.

Enriching Exploration with Geographic Data, 3-D Scans, and Sound

Beyond describing relationships between species, the framework integrates multiple layers of biological information to provide richer exploratory experiences. One important component is **geographic metadata.**

Many biological records include information about where organisms were collected or where species occur. By linking this data in the visualisation, users can connect evolutionary patterns with geographic distributions. The system also incorporates three-dimensional scans of biological specimens. Digital models of organisms can be embedded directly within the visualization environment.

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In some cases, the experience can also include species-specific sonification, such as recorded bird songs to recognize species. Sounds provide an additional sensory dimension connecting the data to recognizable features of real ecosystems.

Together, these elements transform the data into a richer exploratory environment that combines spatial cues, digital specimens, and environmental context.

Communicating Biological Narratives: From Insects to Human Migrations

One of the most promising aspects of the project lies in its ability to support **scientific storytelling.** Biological research often involves narratives that unfold across long timescales and large geographic regions; within the OpenSpace environment, these processes can be organized into guided explorations of biological datasets. Researchers and educators can construct narratives that move through different clusters of species, trace evolutionary pathways, or illustrate patterns of biodiversity across regions.

For example, visualisations may highlight the extraordinary diversification of insect species, explore the evolutionary relationships between birds and mammals, or illustrate patterns like the global migration of human populations. By navigating through the spatial representation of the data, users can observe how these stories emerge directly from the underlying biological information.

Because the system is interactive, audiences are not limited to a fixed presentation. Instead, they can explore the dataset dynamically, discovering relationships and patterns as they move through the experience.

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Expanding the Toolkit for Biological Visualization

The research article demonstrates how tools developed for one field can meaningfully support research and communication in another. Within the ARISE project, this approach shows how interdisciplinary collaboration can generate practical tools for exploring large scientific datasets.

Rather than replacing existing analytical methods, this framework complements them by offering a spatial perspective on complex data. As biological datasets continue to grow, visualisation approaches that support exploration across multiple scales will become increasingly valuable.

Projects like this highlight how cross-disciplinary collaboration can expand the ways scientists analyse data and communicate the structure of the natural world.

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