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Interactive visualization and topology-based analysis of large-scale time-varying remote-sensing data: challenges and opportunities

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Over the last few years, the amount of large and complex data in the public domain has increased enormously and new challenges arose in the representation, analysis and visualization of such data. Considering the number of space missions that provided and will provide remote sensing data, there is still the need of a system that can be dispatched in several remote repositories and being accessible from a single client of commodity hardware.

To tackle this challenge, at the DLR Institute for Software Technology we have defined a dual backend frontend system, enabling the interactive analysis and visualization of large-scale remote sensing data. The basis for all visualization and interaction approaches is CosmoScout VR, a visualization tool developed internally at DLR, and publicly available on Github, that allows the visualization of complex planetary data and large simulation data in real-time. The dual component of this system is based on an MPI framework, called Viracocha, that enables the analysis of large data remotely, and allows the efficient network usage about sending compact and partial results for interactive visualization in CosmoScout as soon as they are computed.

A node-based interface is defined within the visualization tool, and this lets a domain expert to easily define customized pipelines for processing and visualizing the remote data. Each “node” of this interface is either linked with a feature extraction module, defined in Viracocha, or to a rendering module defined directly in CosmoScout. Being this interface completely customizable by a user, multiple pipelines can be defined over the same dataset to enhance even more the visualization feedback for analysis purposes.

Being an ongoing project, on top of these tools, as a novel strategy in EO data processing and visualization, we plan to define and implement strategies based on Topological Data Analysis (TDA). TDA is an emerging set of technique for processing the data considering its topological features. These include both the geometric information associated to a point, as well all the non-geometric scalar values, like temperature and pressure, to name a few, that can be captured during a monitoring mission. One of the major theories behind TDA is Discrete Morse Theory, that, given a scalar value, is used to define a gradient on such function, extract the critical points, identify the region-of-influence of each critical point, and so on. This strategy is parameter free and enables a domain scientist to process large datasets without a prior knowledge of it.

An interesting research question, that it will be investigated during this project is the correlation of changes of critical points at different time steps, and the identification of deformation (or changes) across time in the original dataset.