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PVGeo: an open-source Python package for geoscientific visualization in VTK and ParaView

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Software

- Review
- Repository
- Archive

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Summary

PVGeo is an open-source Python package for geoscientific visualization and analysis, harnessing an already powerful software platform: the Visualization Toolkit (VTK) and its front-end application, ParaView. The VTK software platform is well-maintained, contains an expansive set of native functionality, and provides a robust foundation for scientific visualization, yet the development of tools compatible with geoscience data and models has been limited. As a software extension package to VTK and ParaView, PVGeo addresses the lack of geoscientific compatibility by creating a framework for geovisualization. PVGeo aims to make the process of importing geoscience data into VTK-based software fluid and straightforward for users while providing a framework for new features that avoids the typical, ambitious programming endeavor of building VTK software plugins. We have developed this code library, PVGeo, to link geoscientific data and models with VTK-based 3D rendering environments like ParaView: an open-source platform built on top of VTK (Ayachit, 2015). Since VTK is an established and robust visualization platform, it provides a rich toolbox of features common for visualization and spatial analysis across disciplines (Schroeder, Lorensen, & Martin, 2006). Examples of standard features include volume rendering, glyphing, subsetting, K-Means clustering, volume interpolation, iso-contouring, and Virtual Reality (Ayachit, 2015; Schroeder et al., 2006). By linking geoscience to VTK and ParaView, geoscientists can harness all of the native tools within ParaView, and other VTK powered libraries like ParaViewWeb (Jourdain, Ayachit, & Geveci, 2010), VTK.js (Kitware, Inc., 2019), and PyVista (Sullivan & Kaszynski, 2019) or extend that data into new domains like Virtual Reality, as outlined in Figure 1. PVGeo couples geoscientific information to software libraries at the forefront of scientific visualization, which enables scientists to cost-effectively and reproducibly communicate their findings.

Background

The results of geophysical imaging techniques often hold high significance to stakeholders yet the effective perception of those results remains a dynamic challenge. In the geosciences and especially the field of geophysics, researchers often need 3D and 4D (time-varying) visualizations to understand complex spatial and temporal relationships in data which are challenging to capture in 2D visualizations (Witter & Melosh, 2018). Better perceptions or new understandings may arise from data when referenced in relation to intuitive features like topography, well locations, survey points, or other known information. Through these spatial relations, geoscientists and stakeholders can directly engage with their data to gain insight and begin to rapidly evaluate data and models either on various 2D planes simultaneously or in a complex 3D environment (Carr, Buchanan, Adkins-Heljeson, Mettille, & Sorensen, 1997; Witter & Melosh, 2018).

Geoscientists often use specific visualization software for different data processing routines which can lead to using several different visualization environments for a single project. Unfortunately, geoscientists are often left without a toolset for visual integration across those

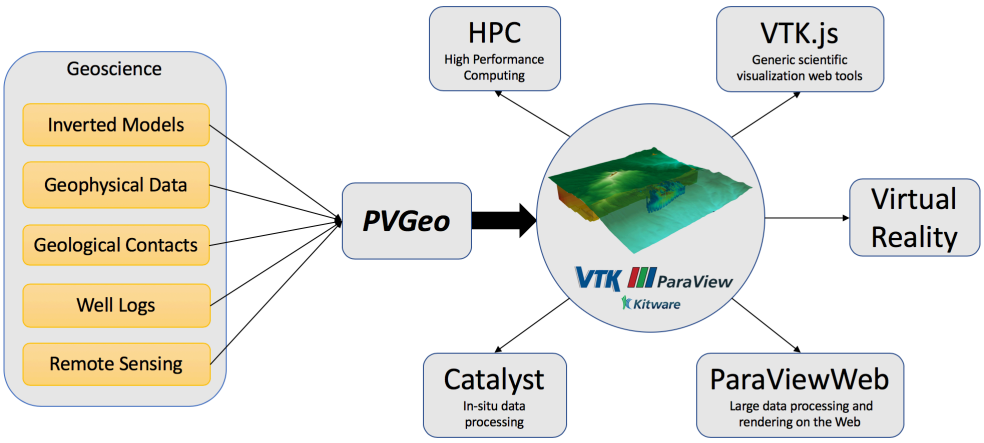

Figure 1: PVGeo providing a link for geoscience to the VTK and ParaView realm of data visualization.

different data types, like pairing well locations, resource models, and geological models, which can hinder their ability to interpret the spatial relationships of varying data types.

As authors of this software and geoscientists, we rely on calibrating and integrating our data with all types of subsurface information to further illuminate the value of geophysical imaging techniques. This fosters a need for a visualization package to work seamlessly across data types and formats that extends the functionality of an already robust visualization platform like ParaView (Ayachit, 2015) or PyVista (Sullivan & Kaszynski, 2019). This visualization library is the PVGeo Python package; a free and open-source library for integrating geoscientific datasets in a common rendering environment to address various visualization and spatial analysis needs in geoscience. The PVGeo package is powered by VTK (Schroeder et al., 2006) and provides plugins for ParaView. As a pure-Python package, PVGeo is interoperable with other Python and VTK-based software like the PyVista Python package (Sullivan & Kaszynski, 2019).

There are various software available for geoscientific visualization; however, these software often handle a few proprietary data formats and are closed-source with licensing fees. Witter & Melosh (2018) provide a comprehensive list and discussion of the various software packages and finds that there are many platforms available for integrated visualizations for limited data types. Having the ability to visually fuse datasets, construct 3D models, or generate horizons within the visualizations can be what separates closed-source software from open-source software (Witter & Melosh, 2018) - development of PVGeo aims to create an open-source alternative for researchers.

Mentions

Development for PVGeo is complemented by development for PyVista. PVGeo provides an extension package to PyVista linking data formats and filtering routines common in geoscientific disciplines to PyVista's generalized framework for 3D visualization. PVGeo leverages PyVista to make the inputs and outputs of PVGeo algorithms more accessible so that users can create compelling, integrated visualizations of their work in a reproducible workflow.

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References

Ayachit, U. (2015). The paraview guide: A parallel visualization application.

Carr, T. R., Buchanan, R. C., Adkins-Heljeson, D., Mettille, T. D., & Sorensen, J. (1997). The future of scientific communication in the earth sciences: The impact of the internet. *Computers and Geosciences*, *23*(5), 503–512. doi:10.1016/S0098-3004(97)00032-0

Jourdain, S., Ayachit, U., & Geveci, B. (2010). Paraviewweb, a web framework for 3d visualization and data processing. In *IADIS international conference on web virtual reality and three-dimensional worlds* (Vol. 7, p. 1).

Kitware, Inc. (2019, June). VTK.js. Retrieved from https://github.com/Kitware/vtk-js

Schroeder, W. J., Lorensen, B., & Martin, K. (2006). *The visualization toolkit (4th ed.)*. Kitware, Inc.

Sullivan, C. B., & Kaszynski, A. (2019). PyVista: 3D plotting and mesh analysis through a streamlined interface for the visualization toolkit (VTK). *Journal of Open Source Software*, *4*(37), 1450. doi:10.21105/joss.01450

Witter, J. B., & Melosh, G. (2018). The Value and Limitations of 3D Models for Geothermal Exploration. *43rd Workshop on Geothermal Reservoir Engineering, Standford Univeristy*, SGP–TR–213.