Research Project Highlight

Fluid–Structure Interaction and Python Scripting Capabilities in OpenSees

Project # 1135-NCTRMZ

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Start-End Dates:
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Abstract
Building upon recent advances in OpenSees, the goals of this project are to expand the framework's Python scripting capabilities and to further develop its fluid–structure interaction (FSI) simulation capabilities, which are based on the particle finite-element method (PFEM). From the start of their development, the FSI modules in OpenSees have been based on Python scripting, and to accomplish FSI simulations in OpenSees, Python commands have been added for a limited number of pre-existing element and material commands available in OpenSees, e.g., linear-elastic triangle elements and beam–column elements with *Concrete01*/*Steel01* fiber sections. However, hundreds of constitutive models and element formulations remain to be incorporated under the Python umbrella for FSI and general OpenSees use. The original scripting language, Tcl, in OpenSees is string-based, powerful, and easy to learn; however, it is not suited for mathematical computations. Recent trends in scripting languages for engineering applications have embraced more general, scientific languages such as Python, which has evolved to a large community with numerous libraries for numerical computing, data analysis, scientific visualization, and web development. Extending OpenSees to Python will help OpenSees keep pace with new scripting developments from the scientific computing community and make the framework more accessible to graduate students who likely have learned Python as undergraduates.

Deliverables
The FSI module, which has been implemented in OpenSees, will be further improved with higher order nonlinear fluid elements, two-phase flows, background meshing procedures, particle-boundary contact, and new numerical solvers. These improvements of FSI will increase the usability of FSI for OpenSees users and move its state from sole research to practical applications. The enhancements to the FSI modules of OpenSees will be validated against available experimental data, including wave flume data from PWRI in Japan that formed the basis for a PEER-sponsored 2014 modeling workshop as well as data collected in FSI experiments at Oregon State University. The framework of Python scripting in

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OpenSees has been summarized in the paper *OpenSeesPy: Python Library for the OpenSees Finite Element Framework.*" As a result of the proposed project, the complete Python library for OpenSees will be implemented with all current OpenSees elements, materials, and other commands. A documentation of the new "OpenSeesPy" interpreter will be created and made publicly available online along with examples and tutorials.

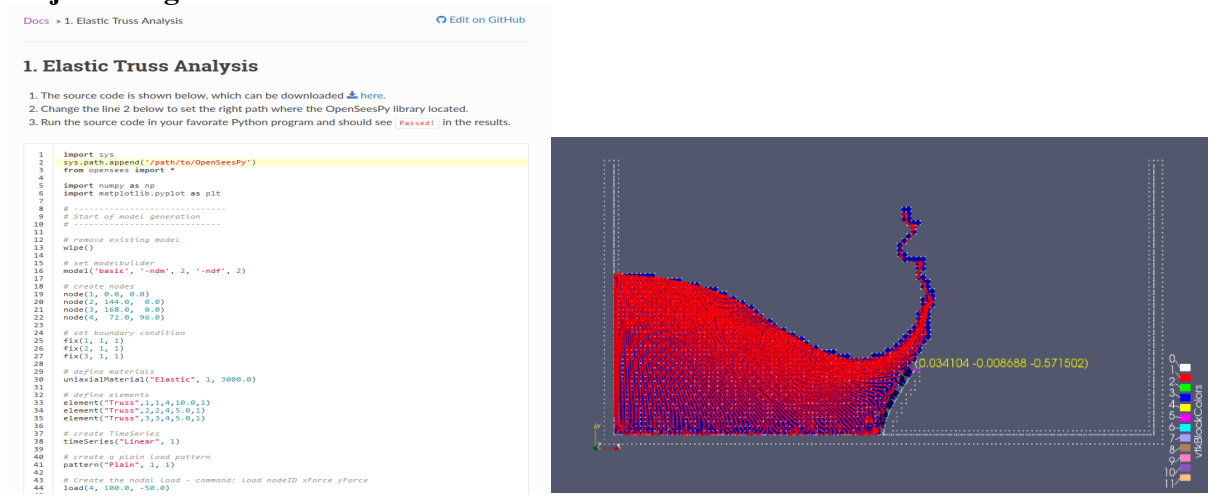
Research Impact

This project will increase the user base of OpenSees with the popular Python interpreting and improve the user experience of OpenSees with a friendlier user interface. The wide array of libraries available in Python, e.g. numpy, pandas, etc., will allow OpenSees to be used in a variety of Python-based applications. The continued development of OpenSees for FSI via the PFEM will support the development of fragility curves and other structural engineering applications using the nonlinear structural models with which current OpenSees users feel most comfortable.

References

Zhu M., McKenna F., Scott M.H. (2018). OpenSeesPy: Python library for the OpenSees finite element framework, *SoftwareX*, 7:6–11.

Project Image



(a) OpenSeesPy webpage for a simple elastic truss analysis in Python and (b) screenshot of Fluid-Structure Interaction simulation using OpenSeesPy.

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