The Journal of Open Source Software

rsudp: A Python package for real-time seismic monitoring with Raspberry Shake instruments

Ian M. Nesbitt[*1, 2], **Richard I. Boaz**[1], **and Justin Long**[3]

1 Raspberry Shake, S.A. **2** School of Earth and Climate Sciences, University of Maine **3** Waterbear Energy

DOI: 10.21105/joss.02565

Software

- Review
- Repository
- Archive

Editor: Jed Brown

Reviewers:

- @eileenrmartin
- @fwalter

Submitted: 12 June 2020
Published: 31 December 2020

Statement of Need

The uses of low-cost seismographs in science and education are becoming more widely known as these devices become more popular (Anthony et al., 2018; Diaz et al., 2020; Subedi et al., 2020; Walter et al., 2019). Raspberry Shake seismographs are commonly used in schools, by Shake community members, and other individuals having no formal training in seismology. The existence of this class of instruments highlighted the need for easy-to-use visualization and notification software to complement these devices. Because all Raspberry Shake instruments are able to forward data as user datagram protocol (UDP) packets, taking the opportunity to exploit the existence of this streaming data was obvious.

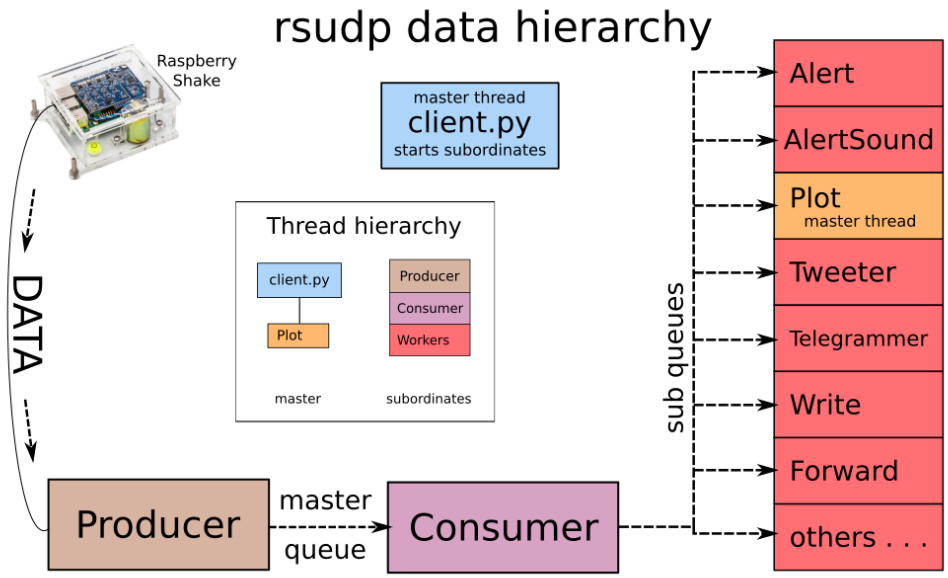

Figure 1: Chart of producer and consumer threads and the organization of data flow in `rsudp`. In order to maximize computational efficiency, features are broken into modules—each module constituting a thread—and data is passed to each module through an asynchronous queue. Inset: thread hierarchy and ownership chart, color-coded by function. Note that the Plot module is owned by the main thread, since `matplotlib` objects can only be created and destroyed by the main thread.

*Corresponding author

The Journal of Open Source Software

Summary

`rsudp` is a multi-featured, continuous monitoring tool for both Raspberry Shake seismographs, used to record both weak and strong ground motion—and Raspberry Boom pressure transducer instruments, used to record infrasound waves. To encourage hands-on community involvement, `rsudp` is open-source, written in Python, and utilizes easy-to-use tools common to the seismology community, including `matplotlib` visualizations (Hunter, 2007) and the `obspy` seismic framework for Python (Beyreuther et al., 2010; Krischer et al., 2015; Megies et al., 2011). `rsudp` is multi-threaded and architected according to a modular producer-consumer data-flow paradigm (Figure 1). The detection algorithm employs a recursive short-term/long-term average ratio (STA/LTA) computation threshold function from `obspy`, executed repeatedly within a loop over the incoming data.

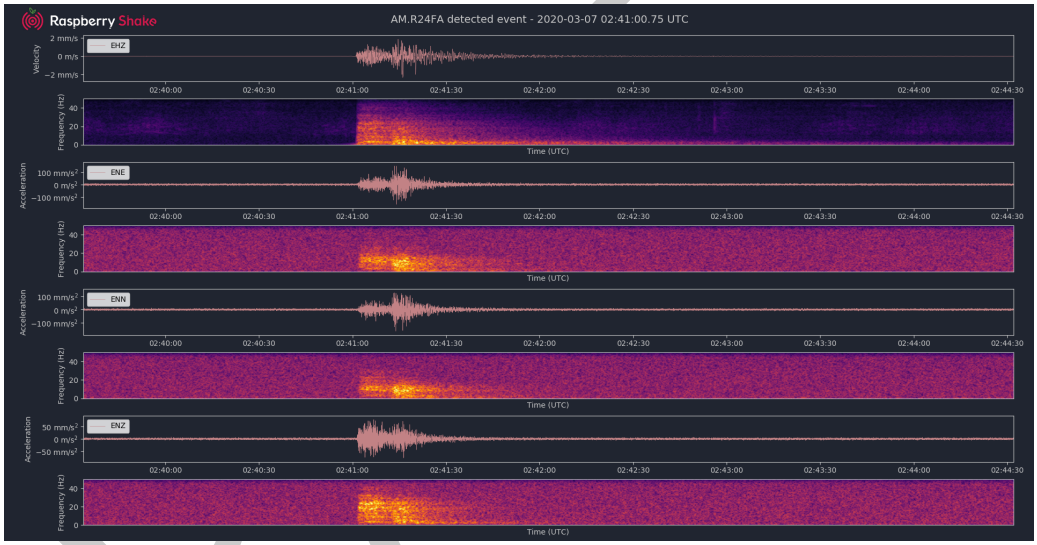

Figure 2: An earthquake trace plotted with a spectrogram on multiple data channels in `rsudp`. The spectrograms are a representation of the fraction of maximum frequency power of the signal on each channel over the duration of the plot. Note that the first channel is data recorded with a geophone (EHZ), and the next three are accelerometers (ENE, ENN, ENZ).

`rsudp` can be used by seismologists as a data analysis tool operating in real time, and as a way for students, citizen scientists, and other end-users to easily visualize and conceptualize live-streaming seismic data (Figure 2). Using the application's simple and straightforward framework, power-users can run their own custom code in the case of detected strong motion. The distribution already contains many useful data-processing modules, including: sound alerts, automated and instantaneous social media notifications, data-forwarding, real-time seismic amplitude (RSAM) forwarding, integrated logging, a miniSEED data archiver, and external script execution (for example, to control input/output pins or some other programmable action). The combination of speed, easy-to-interpret visualization, and ease of customization makes `rsudp` a valuable and instructive companion to the Raspberry Shake family of instruments for researchers, students, and amateur seismologists alike.

Acknowledgements

Financial support for this project comes from Raspberry Shake S.A. We are grateful to Trinh Tuan Vu for his help authoring Windows setup scripts, Branden Christensen for helpful reviews and guidance, and to Leif Lobinsky for design input.

References

Anthony, R. E., Ringler, A. T., Wilson, D. C., & Wolin, E. (2018). Do Low-Cost Seismographs Perform Well Enough for Your Network? An Overview of Laboratory Tests and Field Observations of the OSOP Raspberry Shake 4D. *Seismological Research Letters*, *90*(1), 219–228. https://doi.org/10.1785/0220180251

Beyreuther, M., Barsch, R., Krischer, L., Megies, T., Behr, Y., & Wassermann, J. (2010). ObsPy: A Python Toolbox for Seismology. *Seismological Research Letters*, *81*(3), 530–533. https://doi.org/10.1785/gssrl.81.3.530

Diaz, J., Schimmel, M., Ruiz, M., & Carbonell, R. (2020). Seismometers within cities: A tool to connect earth sciences and society. *Frontiers in Earth Science*, *8*, 9. https://doi.org/10.3389/feart.2020.00009

Hunter, J. D. (2007). Matplotlib: A 2D graphics environment. *Computing in Science & Engineering*, *9*(3), 90–95. https://doi.org/10.1109/MCSE.2007.55

Krischer, L., Megies, T., Barsch, R., Beyreuther, M., Lecocq, T., Caudron, C., & Wassermann, J. (2015). ObsPy: A bridge for seismology into the scientific python ecosystem. *Computational Science & Discovery*, *8*(1), 014003. https://doi.org/10.1088/1749-4699/8/1/014003

Megies, T., Beyreuther, M., Barsch, R., Krischer, L., & Wassermann, J. (2011). ObsPy – what can it do for data centers and observatories? *Annals of Geophysics*, *54*(1), 47–58. https://doi.org/10.4401/ag-4838

Subedi, S., Hetényi, G., Denton, P., & Sauron, A. (2020). Seismology at school in nepal: A program for educational and citizen seismology through a low-cost seismic network. *Frontiers in Earth Science*, *8*, 73. https://doi.org/10.3389/feart.2020.00073

Walter, J. I., Ogwari, P., Thiel, A., Ferrer, F., Woelfel, I., Chang, J. C., Darold, A. P., & Holland, A. A. (2019). The Oklahoma Geological Survey Statewide Seismic Network. *Seismological Research Letters*, *91*(2A), 611–621. https://doi.org/10.1785/0220190211