Learning ambient noise analysis with Raspberry Pi and accelerometers

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Seismograms that we analyze in seismology are not always associated with earthquakes. The Earth's surface is always shaking primarily from oceanic noise due to tidal forces. Analyzing this ambient noise is attracting much attention in seismology for its potential for estimating crustal structure without earthquakes. We developed an educational material to present such a frontier technique in seismology, in which we analyze seismic waves in a more general sense.
Specifically, we connect small accelerometer chips, which are considered to be seismographs, to Raspberry Pi and mimick ambient noise analyses. Two LIS3DH sensors transfer three-dimensional acceleration data to Raspberry Pi through serial communications based on SPI protocol. Raspberry Pi calculates cross-correlation functions of previous five-second seismograms of the station-pair every one second. By multiplying the differential travel time by seismic velocity, we get the distribution of seismic energy as a function of differential travel distances. LEDs connected to the Raspberry Pi display the function so that the system works as a stand-alone real-time source locater. The current system considers two-dimensional data for the simplicity of the system and coding but can be upgraded to three-dimensional as an advanced assignment.
While this tool can be used to determine source location assuming seismic velocity as mentioned above, we can also estimate the seismic velocity using this for a known source. The material perfectly suits for learning frontiers in seismology, including ambient noise analyses and back-projection analyses, but is suitable for learning programming or digital circuit in a more general sense.
We release this material in an outreach event at the Tokyo Institute of Technology in March 2020. We also introduce slow earthquakes, which is another hot topic in seismology, by providing how to analyze seismicity using the "Slow Earthquake Database".

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