Detection of crustal deformation utilizing InSAR Analysis and Machine Learning Algorithms

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Advances in Interferometric Synthetic Aperture Radar (InSAR) data acquisition methods makes large geodetic datasets available including the Earth surface images with temporal resolution of a few days. The InSAR data measures changes in distance at millimeter- or centimeter-level at high spatial resolution, but atmospheric effects cause errors that can obscure small surface displacement signals with routine geodetic data analysis methods. In addition, topography, vegetation, and rainfall are other noise sources in InSAR datasets. In this study, we separate the anomalies associated with noise, monitor and detect surface displacement patterns associated with fault slip at depth and transient deformation signals with duration on the order of weeks using deep learning algorithms. We implement a generative adversarial neural operator model to learn conditional noise distributions. Using the trained model, we build a new synthetic dataset of noise samples for denoising InSAR data and implement a new deep learning model for denoising InSAR data. We are particularly interested in discovery of new signal classes or deformation processes that are buried in the noise, but may occur much more frequently. The final goal of this project is to recognize the effects of different crustal processes on surface deformation patterns and further apply the results in natural hazard analysis. The ARIA (Advanced Rapid Imaging and Analysis) project at JPL and Caltech has been processing InSAR data from the Copernicus Sentinel-1 satellites with the goal to generate prototype interferometry products in near real-time that improve awareness for disaster response and the NASA's NISAR (NASA-ISRO Synthetic Aperture Radar) mission is planned to measure Earth's dynamic surface using InSAR data with a longer radar wavelength than Sentinel-1 to improve measurements in many areas such as risk assessment and geologic hazards. Our proposed project will maximize the scientific return from the ARIA project and the NISAR mission.

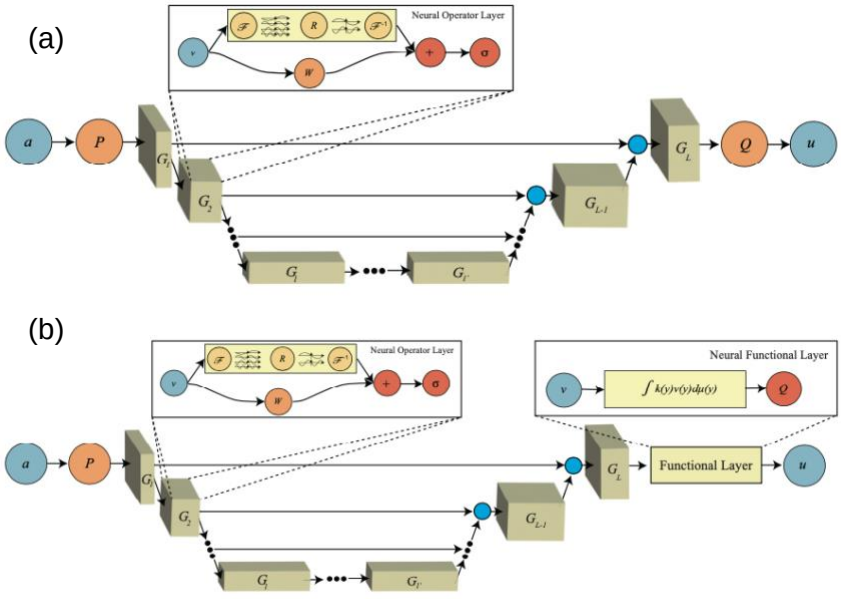

Figure. Generative adversarial neural operator (GANO); (modified from Rahman et al., 2022); (a) Generator. u = G(a). (b) Discriminator. r = d(u).