Detection of slow-moving landslides in large area using InSAR phase-gradients stacking and YOLOv3

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Landslide is one of the major geohazards that endangers the human society and threatens the safety of life and properties. In recent years, attentions have been paid to the Synthetic Aperture Radar interferometry (InSAR) for landslide monitoring with many successful applications. However, it is still difficult to effectively and automatically identify slow-moving landslides distributed in a large area because of phase unwrapping errors, troposphere turbulence and vegetation cover. Here we propose a method combining phase-gradient stacking and the widely-used neural network for tiny object detection: You Only Look Once (YOLOv3) to detect slow-moving landslides from large-scale interferograms. Using the time-series Sentinel-1 SAR images acquired since 2016, we develop a burst-based, phase-gradient stacking algorithm to sum up phase gradients along the azimuth and range directions of short-temporal-baseline interferograms. The stacked phase gradients clearly present the characteristics of localized surface deformation, mainly caused by slow-moving landslides, avoiding the errors result of multiple phase unwrapping in time-series analysis and atmospheric effects. We then train the YOLOv3 network with the stacked phase-gradient maps of known landslides to achieve the quick and automatic landslide detection. We apply our method in the middle section of the Yalong River in mountainous area of western China, with an area of 180,000 km². In addition to the slides that have been published in the inventory, we identify many more slow-moving landslides that cannot be detected by traditional time-series InSAR analysis methods. Our results demonstrate the potential usage of the proposed methods for slow-moving landslide detection in large area, which can be applied before the time-consuming time-series InSAR analysis.