GAN and U-net abilities to automate tectonic fault mapping in remote sensing optical images

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Tectonic faults are the source of earthquakes. They commonly form dense multi-scale networks including a master fault and multiple secondary faults and fractures. Documenting the organization and hierarchy of fault networks is among key information to understand the earthquake process. Generally, faults are identified through the traces they form at the ground surface. So far, these traces have been mapped manually, in the field or in remote sensing images. Yet this manual mapping requires tremendous time and relies on expert knowledge, which may not be available. Here, we explore U-net and Generative Adversarial Network (GAN) abilities to automate fracture and fault identification and mapping in remote sensing optical images. We use expert mapping to teach the models how faults look like in the images, and hence conduct supervised learning. U-net is made of different convolutional layers that extract key features from the images and learn from the expert mapping how to identify the faults. GAN consists of two networks, a Generator and a Discriminator. The Generator has the U-net architecture. It recognizes the fault patterns in the images and generates synthetic faults maps. The Discriminator, whose architecture is that of half of the U-net, discriminates the expert and the synthetic maps, and sends its feedback to the Generator. This allows the Generator to progressively minimize the difference between the synthetic and the expert maps. To identify and map faults at the greatest resolution, we have developed a new loss function based on a combination of Mean Squared Error and Recall. We used two criteria to measure and compare the generalization performance of the GAN and U-net architectures. The qualitative and quantitative comparison of the two methods demonstrates the superiority of U-net for fault and fracture mapping in remote optical images. Machine learning with U-net has thus the potential to greatly assist geophysicists in documenting seismogenic faults.