Bayesian optimization of fault-shape parameters using finite element analysis: parameter sets for strong slip partitioning

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The Bayesian optimization algorithm is now a key technique in various scientific and engineering fields that require the parameter optimization. The technique can reduce the number of simulation trials as compared with the grid-search because the algorithm can act as an artificial intelligence with a statistical decision-making. Because a three-dimensional finite element analysis (FEA) for seismic faulting consumes much CPU time, the use of the Bayesian optimization with the FEA is logical and is expected to accelerate the parameter detection process.

Here, I present the method of combining an open source library Optuna (1) based on a Bayesian optimization algorithm, Tree-Structured Parzen Estimator (TPE) with the seismic faulting FEA based on COMSOL Multiphysics and then demonstrate a Baysian optimization for the fault-shape parameters that activates strong slip partitioning.

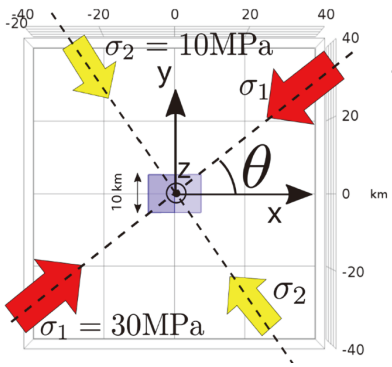
The parameter sets obtained from the Bayesian optimization algorithm result in a stronger slip partitioning than that obtained from the grid-search. More specifically, the optimized parameter set was found as a dip angle for the reverse-slip fault of 54.5 degree, a dip angle for the strile-slip fault of 86.3 degree, and the principal stress direction of 56.1 degree clockwise from the strike direction.

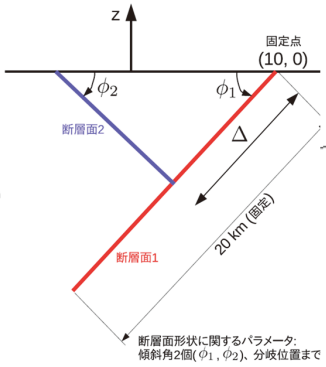
The Bayesian optimization detected the parameter set after 50 trials, whereas the grid-search was composed of 784 trials. In summary, the use of the Bayesian optimization algorithm is an effective and efficient way of a parameter optimization for a seismic faulting simulation that requires long CPU time.

References:

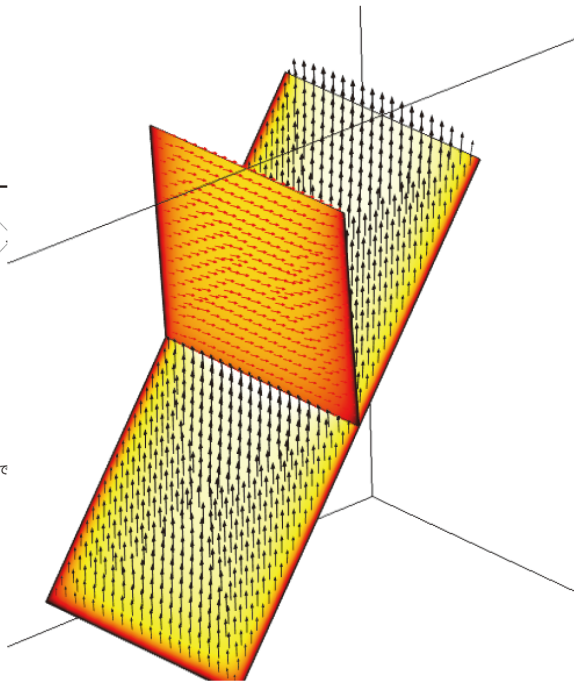
(1) Preferred Networks, Inc.: https://optuna.org/

Keywords: Active Fault, Finite Element Method, Bayesian Optimization, Slip Partitioning





最適化するパラメータ：
主応力方位と断層面形状に関するパラメータ



Θ= 33.8°, ϕ1= 54.5°, ϕ2= 86.3°, Δ=10 km
のとき、スリップパーティショニングが
生じやすいと考える

