Computational feasibility of a 3D local FWI using the Recursive Patched Green Functions method

Janaina Schwarzrock, Edwin Fagua Duarte, Danyelle da Silva, João Medeiros de Araújo (UFRN, Brazil)
Mauro Ferreira (Trinity College Dublin, Ireland)

Abstract

Local solvers are a good alternative to calculate frequency domain wavefields at the target area without the necessity to calculate the wavefield in the entire computational domain. The local solvers can be used to perform a target-oriented Full waveform inversion. Although the efficiency of local solvers has been widely demonstrated in 2D problems, 3D implementation presents some difficulties. The reason for these difficulties is that local solvers require the calculation of Green's Functions related to the boundary of the target area, which turns this problem computationally expensive due to the great number of points of target boundary in a 3D problem. To overcome this problem we use the Recursive Patched Green Function method, which is used in condensed matter physics to calculate Green functions in materials with impurities. In this method, we split the target and the outside target areas into subsystems, and then, these subsystems are connected recursively until form the outside target area. The connection operation is performed by calculating Green's functions related to the connected system from Green's Functions from the unconnected system by using the Dyson equation. The calculation of the outside target area Green's functions is performed once at the beginning of the inversion and this information is kept in memory.

To calculate the Green functions related to the entire computational domain, we connect the target area subsystems to the outside target area in a recursive way, also by using the Dyson equation. The advantage of this method is that when the wave velocity change at the target area, it is necessary to repeat just the target connection because it is possible to use the outside target area Green functions calculated at the beginning. This methodology shows to be faster than conventional wave propagation since it is necessary to invert matrices with a maximum size of the perimeter of the computational domain instead of the volume as in the conventional method. We assess the computational time and the RAM memory used for both conventional and RPGF methods. To do so, we calculate the 3D wavefield at the target varying the size of the entire velocity model and the target accordingly in such a way that the target is about eight percent of the entire computational domain. The calculations are performed using the RPGF method and the conventional method. When comparing both methods we observe that in an FWI scenario where is necessary to perform tens or hundreds of propagation, the RPGF method reduces the computational time by about five to seven times depending on the target and model sizes and it uses around half of RAM memory than the conventional method. We also observe that these values of speed up and memory saving are improved when the size of velocity and target is increased.