A road to the real-time tomography: Huygen's method and recursive inversion scheme

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Seismic tomography has been widely used to estimate heterogeneous velocity structures.
Traditional methods for tomography have some limitations. First, conventional ray tracing methods such as pseudo bending and ray shooting are two-point ray tracing methods. We have to calculate a ray between source and receiver one after another. This type of ray tracing methods does not guarantee the ray connects the source with the receiver, especially in a highly heterogeneous medium. On the other hand, in inversion, we usually calculate the least sqare solution or an iterative solution with large scale matrix. Whenever we get a new data set, we have to solve the entire matrix again.

These two limitations are critical in real-time tomography which renews the former tomography result as soon as a new earthquake occurs. In this study, we first adopt Huygen's method(Saito, 2001). This ray tracing method is based on Huygen's principle and network theory, so we can find first arrival times and raypaths with practical accuracy for any two points even in a very complex medium. Secondly, we use the recursive inversion scheme proposed by Rodgers(1976). With this scheme, we can find the least sqare solution recursively, that is, the solution is updated only by adding a correction term into the former solution. This scheme is also superior to any iterative schemes because a resolution matrix is computed together with the solution at each time.

In addition, we calculate ray paths from receivers to each block of the model space beforehand. We can conduct so-called real-time tomography with the travel time data sets already obtaind in this way and the recursive inversion scheme every time when a new earthquake occurs.

In this study, we show the validity of the present real-time tomography with several numerical experiments. Comparison the result with conventional tomography methods, especially in resolution, the new method can provide the similar pattern and accuracy.