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Simulation of seismic wave propagation for reconnaissance as part of an interaction model in machined tunneling

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During machined tunneling, there is a complex interaction chain of the involved components. For example, on one hand the machine influences the surrounding ground during excavation, on the other hand supporting measures are needed acting on the ground. Furthermore the different soil conditions are influencing the wearing of tools, the speed of the excavation and the safety of the construction site. In order to get information about the ground along the tunnel track, one can use seismic imaging. But interpreting the data can be very difficult because measurements are usually taken inside the tunnel.
To get a better understanding of seismic wave propagation for a tunnel environment, we want to perform simulations with the spectral element method using the software package SPECFEM 2.0 SESAME. This method solves the elastic wave equation by subdividing the simulation domain into elements. The wave field is represented by Lagrangian polynomials of high order. Together with the Gauss-Lobatto-Legendre quadrature to integrate over the elements, one can achieve a diagonal mass matrix of the system. This results in a very fast and accurate method.
For the simulations we use a synthetic 3D geotechnical ground model provided by the TUNCONSTRUCT project from which we produce the mesh. Since the spectral element method can only handle hexahedral elements, it is a challenge to build high resolution meshes containing a tunnel. We deal with this problem by using a special local mesh around the tunnel that we call a tunnel brick which can be inserted into different meshes. Using this technique we can perform high resolution simulations of waves initialized by a single force acting either on the front face or the side face of the tunnel. The aim is to produce waves that travel mainly in the direction of the tunnel track and to get as much information as possible from the backscattered part of the wave field.