Parallelized Construction of Extension Velocities for the Level-Set Method

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The level-set method is widely used to track the motion of interfaces driven by a velocity field. In many applications, the underlying physical model defines the velocity field only at the interface itself. For these applications, an extension of the velocity field to the simulation domain is required. This extension has to be performed in each time step of a simulation to account for the time-dependent velocity values at the interface. Therefore, the velocity extension is critical to the overall computational performance. We introduce an accelerated and parallelized approach to overcome the computational bottlenecks of the prevailing and serial-in-nature fast marching method, in which the level-set function is used to predetermine the computational order for the velocity extension. This allows to employ alternative data structures, which results in a straight forward parallelizable approach with reduced complexity for insertion and removal as well as improved cache efficiency. Compared to the prevailing fast marching method, our approach delivers a serial speedup of at least 1.6 and a shared-memory parallel efficiency of 66% for 8 threads.

Keywords: Velocity Extension, Level-Set Method, Parallel Computing Fast Marching Method.