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Coupling Methods for Mixed Two- and One-Dimensional Models for Time-Dependent Waves

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We propose a method for mixed-dimensional modeling of time-dependent wave problems. A two-dimensional (2D) medium is considered, which includes a part that is assumed to behave in a one-dimensional (1D) fashion. The 2D and 1D regions are separately discretized using 2D and 1D finite element formulations. The coupling of the 2D and 1D regions along their interface is performed weakly, by using the Nitsche Method. The advantage of using the Nitsche method to impose boundary and interface conditions has been demonstrated by several authors, including a previous work demonstrating the viability of this method in the context of mixed-dimensional coupling in elliptic problems; here the viability is shown in the context of hyperbolic problems. The computational aspects of the method are discussed, and it is compared to the slightly simpler Panasenko method numerically. Numerical experiments are presented for two case studies. The performance is investigated for various extents of the 1D region. It is concluded that the Nitsche method is a viable technique for mixed-dimensional coupling of hyperbolic problems of this type.