Sharp error estimates for finite element methods of solving 2nd order hyperbolic problems in the classes of non-smooth data

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Error estimates are presented for three- and two-level FEMs of solving hyperbolic initial-boundary value problems in the Lebesgue or fractional Sobolev/Nikolskii spaces of the right-hand sides and initial data. They are given in uniform in time and L^2- and H^1 space norms. No any a priori assumptions are imposed on solutions. The results and their derivation differ from the elliptic or parabolic cases essentially. The lower error estimates are also derived to confirm sharpness of the results and impossibility to improve them in several ways. The estimates are suitable to exploit in optimal control problems.