Coherent discrete embeddings for Lagrangian and Hamiltonian systems

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The general topic of the present paper is to study the conservation for some structural property of a given problem when discretising this problem. Precisely we are interested with Lagrangian or Hamiltonian structures and thus with variational problems attached to a least action principle. Considering a partial differential equation (PDE) deriving from such a variational principle, a natural question is to know whether this structure at the continuous level is preserved at the discrete level when discretising the PDE. To address this question a concept of \textit{coherence} is introduced. Both the differential equation (the PDE translating the least action principle) and the variational structure can be embedded at the discrete level. This provides two discrete embeddings for the original problem. In case these procedures finally provide the same discrete problem we will say that the discretisation is \textit{coherent}. Our purpose is illustrated with the Poisson problem. Coherence for discrete embeddings of Lagrangian structures is studied for various classical discretisations (finite elements, finite differences and finite volumes). Hamiltonian structures are shown to provide coherence between a discrete Hamiltonian structure and the discretisation of the mixed formulation of the PDE, both for mixed finite elements and mimetic finite differences methods.

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