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Exact space-time symmetry conservation and automatic mesh refinement for classical lattice field theory

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The breaking of space-time symmetries and the non-conservation of the associated Noether charges constitutes a central artifact in lattice field theory. In [1] we have shown how to overcome this limitation for classical actions describing point particle motion, using the world-line formalism of general relativity. The key is to treat coordinate maps (from an abstract parameter space into space-time) as dynamical and dependent degrees of freedom, which remain continuous after discretization of the underlying parameter space. Here we present latest results [2] where we construct a reparameterization invariant classical action for scalar fields, which features dynamical coordinate maps. We achieve the following: 1) global space-time symmetries remain intact after discretization and the associated Noether charges remain exactly preserved 2) coordinate maps adapt to the dynamics of the scalar field leading to adaptive grid resolution guided by the symmetries 3) dynamic coordinate maps contribute to boundary terms, offering new freedom in constructing boundary conditions.

[1] A.R. and J. Nordström "A symmetry and Noether charge preserving discretization of initial value problems" J.Comput.Phys. 498 (2024) 112652 (https://arxiv.org/abs/2307.04490)

[2] A.R., W.A. Horowitz and J. Nordström "Exact symmetry conservation and automatic mesh refinement in discrete initial boundary value problems" (https://arxiv.org/abs/2404.18676)

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