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Symbolic Partial Differential Equations Analysis Using Mathematica

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Abstract : Many symbolic computations and manipulations required in the analysis of partial differential equations (PDE) or systems of PDEs are tedious and error-prone. These computations arise when determining conservation laws, entropies or integral identities, which are essential tools for the study of PDEs. Here, we discuss a new Mathematica package for the symbolic analysis of PDEs that automate multiple tasks, saving time and effort. Methodologies: During the research, we have used concepts of linear algebra and partial differential equations. We have been working on creating algorithms based on theoretical mathematics to find results mentioned below. Major Findings: Our package provides the following functionalities; finding symmetry group of different PDE systems, generation of polynomials invariant with respect to different symmetry groups; simplification of integral quantities by integration by parts and null Lagrangian cleaning, computing general forms of expressions by integration by parts; finding equivalent forms of an integral expression that are simpler or more symmetric form; determining necessary and sufficient conditions on the coefficients for the positivity of a given symbolic expression. Conclusion: Using this package, we can simplify integral identities, find conserved and dissipated quantities of time-dependent PDE or system of PDEs. Some examples in the theory of mean-field games and semiconductor equations are discussed.

Keywords : partial differential equations, symbolic computation, conserved and dissipated quantities, mathematica
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