A Computational Elucidation of Curved Spacetime

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I propose to implement a geometric formulation of curved space time in a functional computer programming language, and to explore the space of simulations and manipulations made possible by such a formulation. A primary motivation is to state the foundations of General Relativity in a non-ambiguous manner.

This work follows several attempts to formulate curved spacetime on computers for the purpose of numerical calculations and algebraic manipulation. Most of these packages are specially designed for the tasks of tensor analysis and/or efficient numerical calculation, as is appropriate for use in calculations. A crucial difference of this proposed work will be to carefully build up the geometric and analytical tools in a general purpose functional programing language (mit-scheme). As a learning and reference tool, this will allow users to explore the inner workings and structure of the system, which I believe is essential to understanding the system as a whole.

The frame field representation will be used to emphasize the geometric properties of curved space time, as opposed to the more traditional coordinate heavy tensor analysis approach.

The resulting work will include a full implementation with source code and documentation, as well as example problems and qualitative comparisons with existing packages and software systems.

References

[1] Functional Differential Geometry, G. Sussman and J. Wisdom (2005)

[2] Structure and Interpretation of Classical Mechanics, G. Sussman and J. Wisdom (2001)

[3] "Algebraic Computing in General Relativity", Ray d'Inverno (from General Relativity, G. Hall and J. Pulham)

[4] "The Use of Algebraic Computing in General Relativity", H. I. Cohen, A. Leringe and Y. Sundblad